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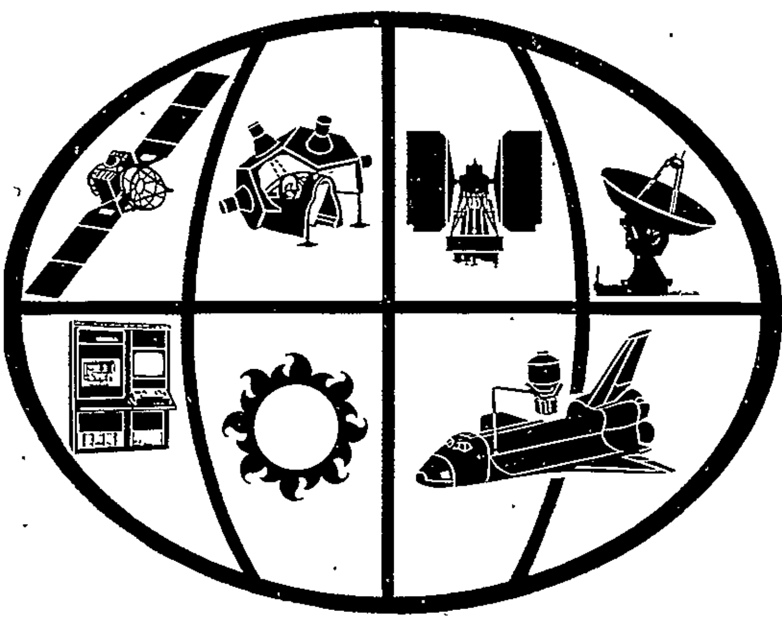
AUTOMATED BIOWASTE SAMPLING SYSTEM FECES MONITORING SYSTEM FINAL REPORT

CONTRACT NAS 9-15159
FOR
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACECRAFT CENTER
HOUSTON, TEXAS 77058



space division

GENERAL ELECTRIC

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AUTOMATED BIOWASTE SAMPLING SYSTEM

FECES MONITORING SYSTEM

FINAL REPORT

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FOREWARD

The Feces Monitoring System (FMS) is an automated system for collecting, measuring and sampling human feces in the Shuttle Orbiter. The FMS was developed under NASA Contract NAS-9-15159 as an extension of NASA Contract NAS 9-11443. The FMS incorporates a micro computer coupled with a servometer controlled slinger to provide fecal mass measurement capability; automated fecal sampling is also provided. This report describes the FMS requirements and the development, fabrication and testing of the engineering model FMS under NASA Contract NAS-9-15159.

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1.0 SUMMARY

The objective of the Feces Monitoring System (FMS) Program was to design, fabricate, assemble and test an engineering model waste collector system (WCS) to be used in support of life science and medical experiments related to Shuttle missions. The FMS design was patterned closely after the Shuttle WCS, including: Interface provisions; mounting; configuration; and operating procedures. These similarities will make it possible to eventually substitute an FMS for the Shuttle WCS of Orbiter. In addition, several advanced waste collection features, including the capability of real-time inertial fecal separation and fecal mass measurement and sampling were incorporated into the FMS design.

The engineering unit of the Feces Monitoring System (FMS) has demonstrated the feasibility of measuring fecal mass and of obtaining fecal samples without the time consuming and handling problems of bag type systems. The FMS concept has been sufficiently developed to overcome most development problems; however, several refinements are required before flight measurement accuracy and user acceptability can be achieved; namely:

1. The microcomputer integration with the slinger design and the servo motor must be optimized. System signal to noise ratio, threshold truncation of data and data manipulation must be better understood for solid fecal masses and interactions determined.
2. Long term users tests must be completed to assess system acceptability and durability.
3. Zero "g" aircraft tests with known sample sizes are needed to calibrate to system for future spaceflight applications.

This report outlines a series of test phases which have lead to a significant improvement in one standard deviation FMS mass measurement calibration from ±9% at the inception of testing to ±7.7% presently. Further improvement in mass measurement accuracy is expected with incorporation of an algorithm in the microcomputer to provide for a highly accurate calibration curve for mass calculation. Since the present system demonstrated ±5% accuracy with a normal 150 gram stool, it is expected to achieve this accuracy over the full range and to possibly achieve ±2% with the normal size defecation.

Basically, the lessons learned in the tests to date have been:

1. The microcomputer is an intricate device which requires exact interfaces and precise application to the desired function. For example, one of the more embarrassing episodes in trouble-shooting the system prior to the onset of Phase III testing was isolated to loose wire connections in the microcomputer.
2. Seemingly minor design decisions radically impacted the system. For example, the normal power limitation assumption resulted in equipping the FMS with an adequate supply for normal functions; however, it did not have the momentary resiliency necessary to quickly re-establish slinger speed after defecation.

In summary, the FMS is a feasible concept for manned spaceflight applications; however, more refinement is required prior to committing to a flight hardware program.

2.0 BACKGROUND

Feces and urine mass and volume determination with attendant sampling is required to support selected biomedical experiments in Shuttle. Previous systems developed to support similar requirements in Skylab were inefficient, in that: (1) They required an inordinate amount of crew manipulation to effect their operation; (2) The systems were excessively large and heavy; and (3) They required an excess amount of direct handling of the biowaste materials by the crewmen. In addition, the requirement for direct crew involvement through lengthy sampling procedures increased the risk of sample loss and/or adulteration.

Under Contract NAS 1-11443, Development of an Advanced Biowaste Sampling System (ABSS), advanced concepts were developed for fecal and urine measurement and sampling systems to support Shuttle biomedical experiments. The concepts were developed, and breadboard hardware was designed and fabricated for demonstrating feces collection, mass measurement and sampling techniques. This Contract (NAS 9-15159) is an extension of the effort initiated under NAS-1-11443. Under NAS 9-15159, an engineering model Feces Monitoring System (FMS) has been designed, fabricated and tested.

3.0 FUNCTION

3.1 Functional Requirements

Conceptually, the FMS is intended to satisfy requirements developed as part of Contract NAS 9-13747 to support Shuttle life science and medical research and diagnostic programs.

Based on the work statement design requirements, and the general system concept, as represented by the previous contract effort, an FMS Engineering Model performance specification was prepared (Appendix A). This design specification defines both primary and secondary performance requirements. Table 3.1-1 lists the major design requirements.

Although optimization for minimum weight, power and size was not required, the operating model was configured to provide both a functional and attractive appearance representative of a possible flight design and for simulation purposes, and to be compatible with the WCS interface.

3.2 Functional Description

3.2.1 General

The Feces Monitoring System (FMS) provides for the collection, mass measurement, sampling and storage of feces in both a one "G" and zero "G" environment. Designed to interface with the Shuttle Waste Collector Subsystems (WCS), the FMS is modular in construction, with all of the principal components of the assembly easily accessible. The commode mounting provisions

TABLE 3.1-1

FMS MAJOR DESIGN REQUIREMENTS

FECES COLLECTION

- o MALE/FEMALE USERS
- o INERTIAL FECAL SEPARATION CAPABILITY
- o PNEUMATIC TRANSPORT
- o MASS
  500 GMS MAXIMUM PER DEFECATION[1]
  15 GMS MINIMUM PER DEFECATION
- o RATE
  0.75 DEFECATIONS PER MAN-DAY AVERAGE[1]

FECES MASS MEASUREMENT

- o EACH DEFECATION
- o REAL TIME
- o ACCOMMODATE DEFECATIONS OF ALL POSSIBLE CONSISTENCIES
- o ERROR, ± 1 GM OR ± 2%, WHICHEVER IS GREATER

FECES SAMPLING

- o USER OPTION
- o COLLECT COMPLETE SAMPLE
- o COMPATIBLE WITH FREEZING OR LYOPHILIZATION
- o CROSS-CONTAMINATION, 0.5 GMS MAXIMUM

SYSTEM

- o SEMI-AUTOMATIC OPERATION
- o 28 VDC POWER INPUT
- o DATA TO TLM
  FECES MASS
  USER ID
  SAMPLE CONTAINER NUMBER
- o CAPACITY, 210 MAN-DAYS MAXIMUM

[1]Based on Skylab data, Feces Data from Skylab, GE PIR 1R60-74-150

are compatible with those of the WCS commode. Figure 3.2.1-1 shows the FMS engineering unit, including an inertial drive seat to assist in stool separation in a zero "G" environment. WCS design features such as vehicle interface, envelope, and user interface have been incorporated into the FMS wherever practical to minimize retraining of the user. The FMS does not provide for the collection of urine, but is intended for use in conjunction with a urine collection system such as the UMS developed under Contract NAS 15230. An Operations, Maintenance and Handling Manual for the FMS is provided in Appendix B.

3.2.2 Collection and Storage

Patterned after the WCS, the FMS provides a collection container or "commode" suitable for the storage of a quantity of feces equivalent to that expected on a 30 day mission by a crew of seven (7).

Collection is provided for by the use of a WCS seat/slide valve assembly. Fecal matter is deposited directly into the commode as part of the act of defecation. The stool is conveyed downward by gravity, or in zero "G", by a transport air stream, until it contacts the slinger assembly. The slinger, a servomotor driven circular flat plate having thirty (30) tines arranged perpendicular to its surface at the periphery, rotates at approximately 2,500 RPM. Upon contacting the slinger tines, the fecal matter is shredded and thrown outward into the commode.

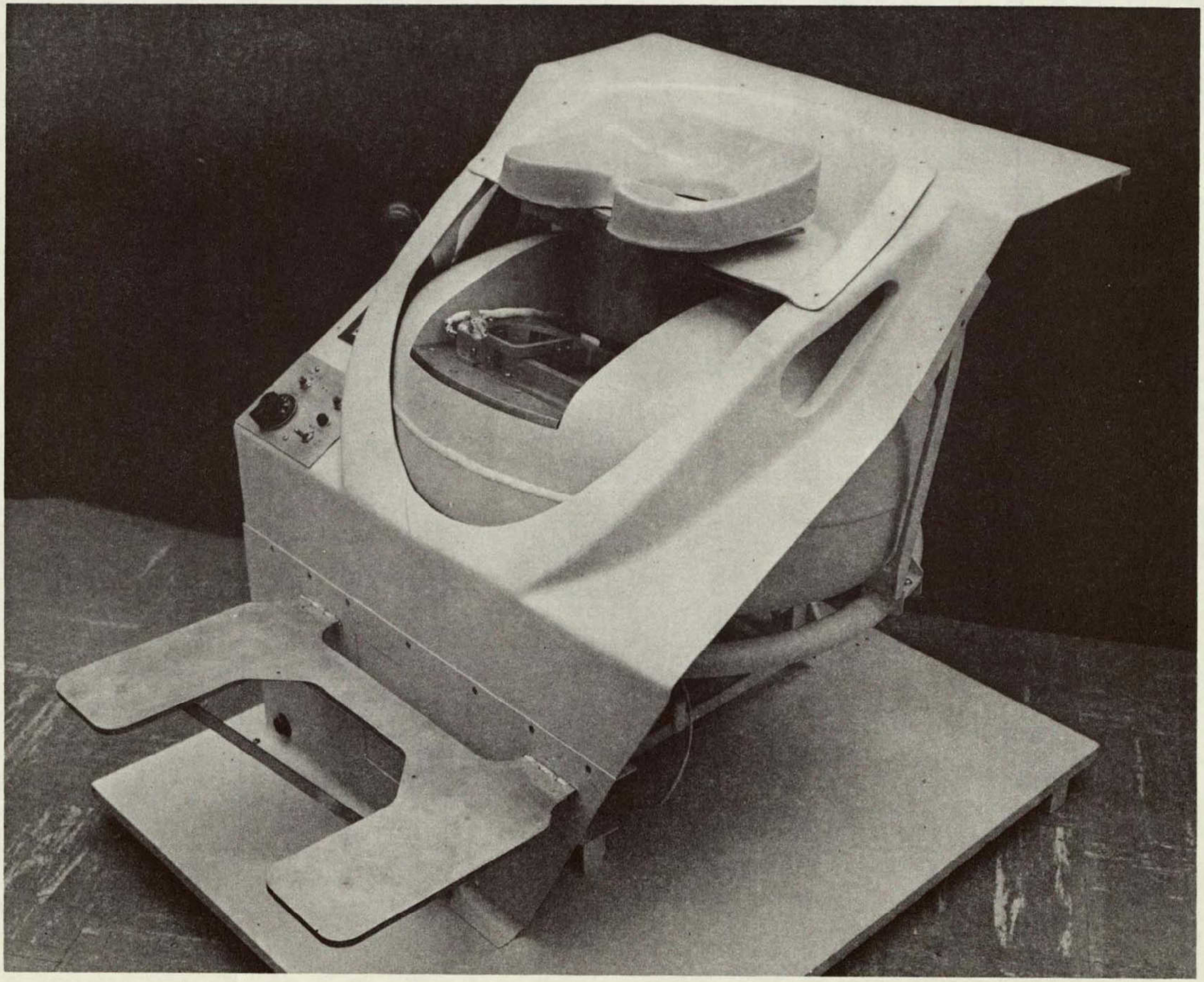

FIGURE 3.2.1-1 FMS ENGINEERING UNIT

At the completion of the defecation process, the fecal matter is dried, resulting in a decreased level of microbiological activity.

3.2.3 Mass Measurement

Mass measurement in the FMS is accomplished through the use of a specially designed servomotor driven slinger assembly schematically shown in Figure 3.2.3-1, and illustrated in Figures 3.2.3-2 and 3.2.3-3. When feces admitted to the commode contacts the slinger, it is shredded and thrown outward toward the side of the commode. As in the WCS, the shredding is intended to aid in drying the feces during storage. In the FMS, however, the acceleration of the feces by the slinger permits the determination of the mass of the material admitted to the commode. When the fecal material contacts the slinger and/or slinger tines, the slinger servomotor, which normally operates at 2,500 RPM, is slowed slightly. The servomotor control circuit senses this change in velocity and compensates for it by increasing the current to the motor, thereby returning it to normal 2,500 RPM speed. The FMS mass measurement concept is based on the proportionality of the change in motor current and the fecal mass. A microcomputer in the FMS continually monitors the current and speed signals from the slinger. When the values for current exceeds a preset threshold, a measurement cycle begins. In this measurement, the area under the curve resulting from the

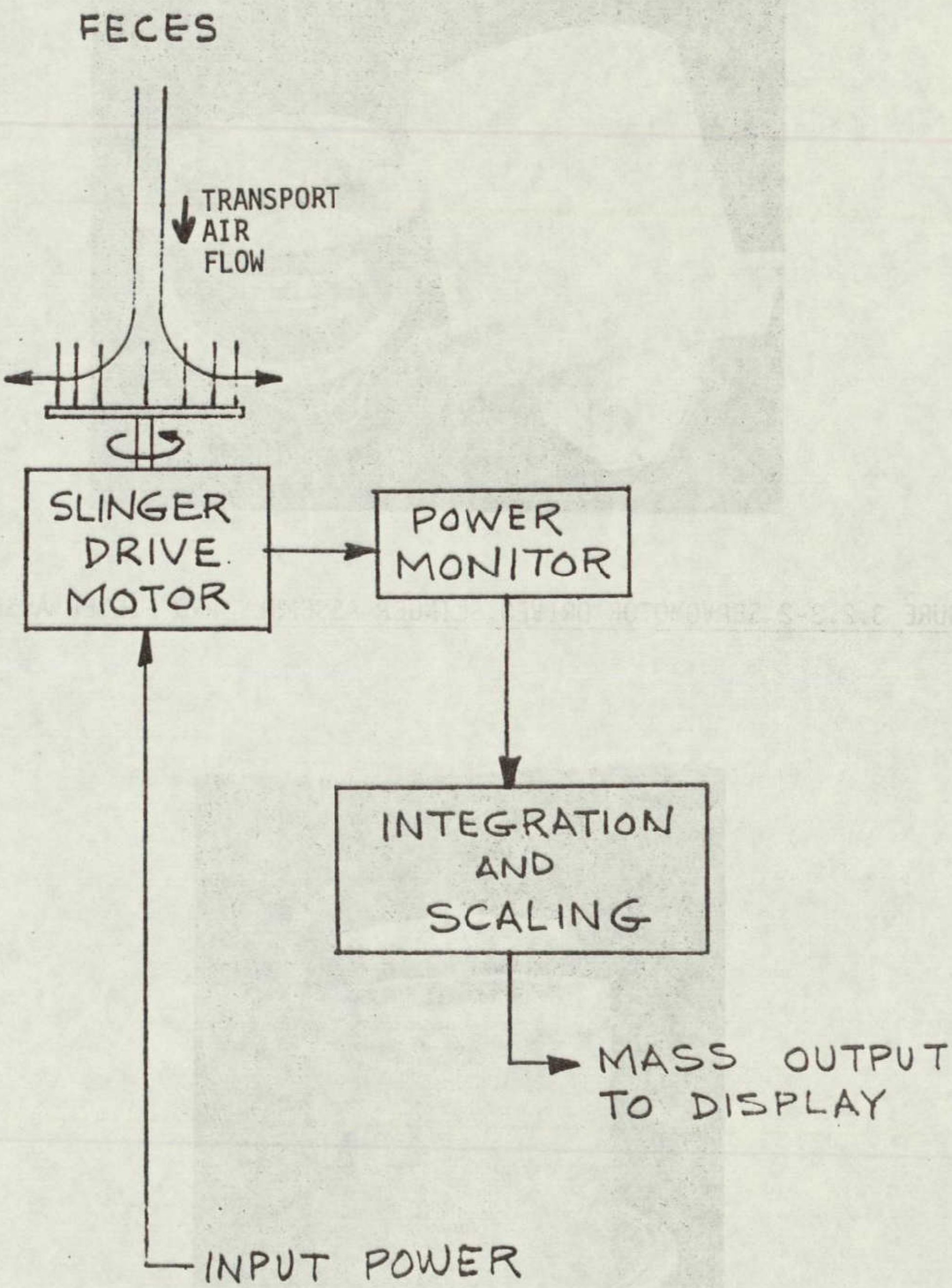

FIGURE 3.2.3-1 SYSTEM BLOCK DIAGRAM FOR FMS

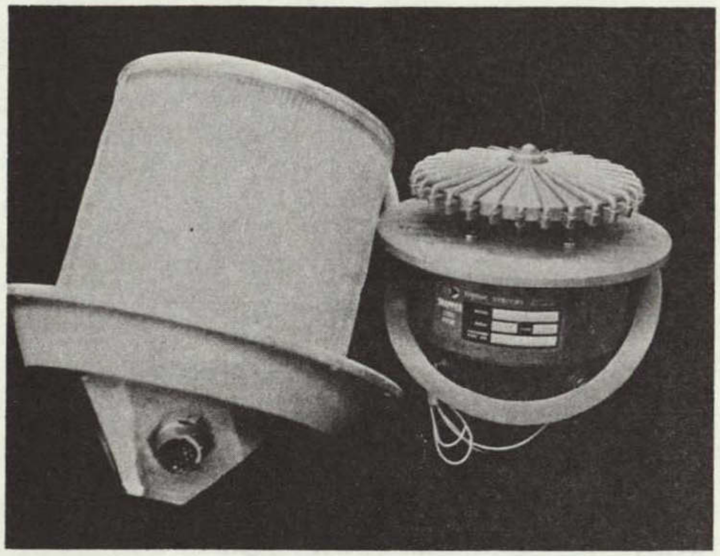

FIGURE 3.2.3-2 SERVOMOTOR DRIVEN SLINGER ASSEMBLY AND FILTER ASSEMBLY

FIGURE 3.2.3-3 INTEGRATED SERVOMOTOR DRIVEN SLINGER ASSEMBLY AND FILTER ASSEMBLY

change in current is integrated. The resulting area is converted to a BCD output signal which is a measure of the mass of the fecal material admitted to the commode. The resultant information is then printed out on the FMS printer along with the USER ID NO., the SAMPLE CAN ID, and the MEASURED MASS of the defecation.

3.2.4 Sampling

Provisions have been made in the FMS to permit collection of fecal samples. Collection can be accomplished without affecting the mass measurement capability. The sampling system shown schematically in Figure 3.2.4-1 consists of a set of sampling canisters, each containing a sampling strip. When a canister is installed in the FMS, the sampling strip is deployed to encircle the slinger wheel. As a result, when fecal material is thrown outward by the action of the slinger, the material impinges on the collection strip instead of the commode. The collection strip surface is designed to retain the material. Upon completion of the defecation, the sampling strip can be withdrawn from around the slinger, and the canister which now will contain the feces sample can be removed from the commode and stored.

3.3 System Description

The FMS is designed to be compatible with the Shuttle WCS envelope as shown in Figure 3.3-1. Figure 3.3-2 and Figure 3.3-3 show the FMS with the cover ON and the cover OFF, respectively.

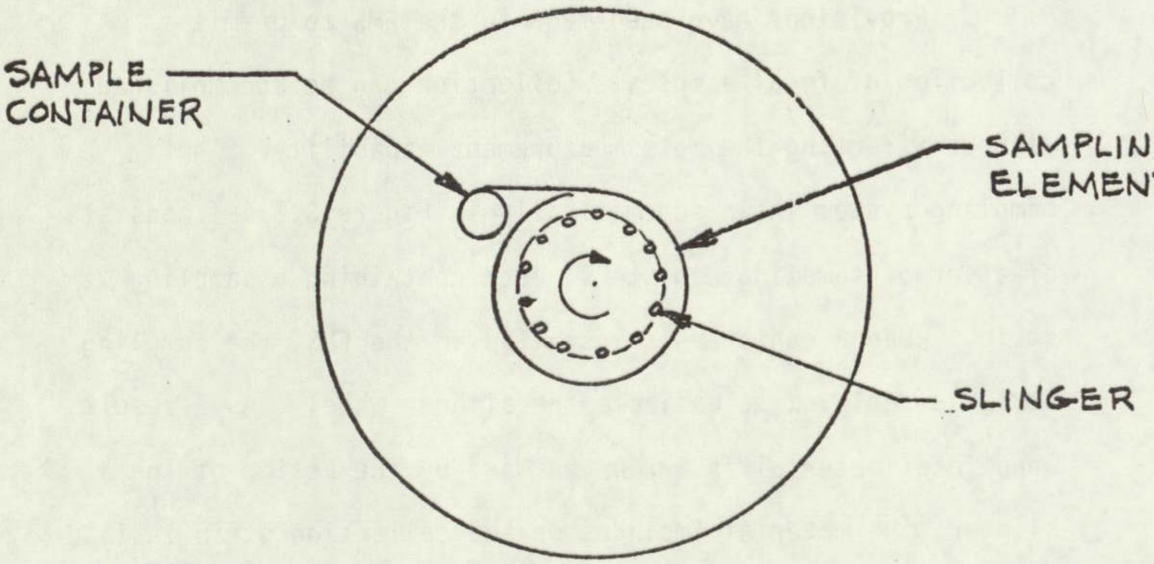

FIGURE 3.2.4-1 FMS SAMPLING CONCEPT

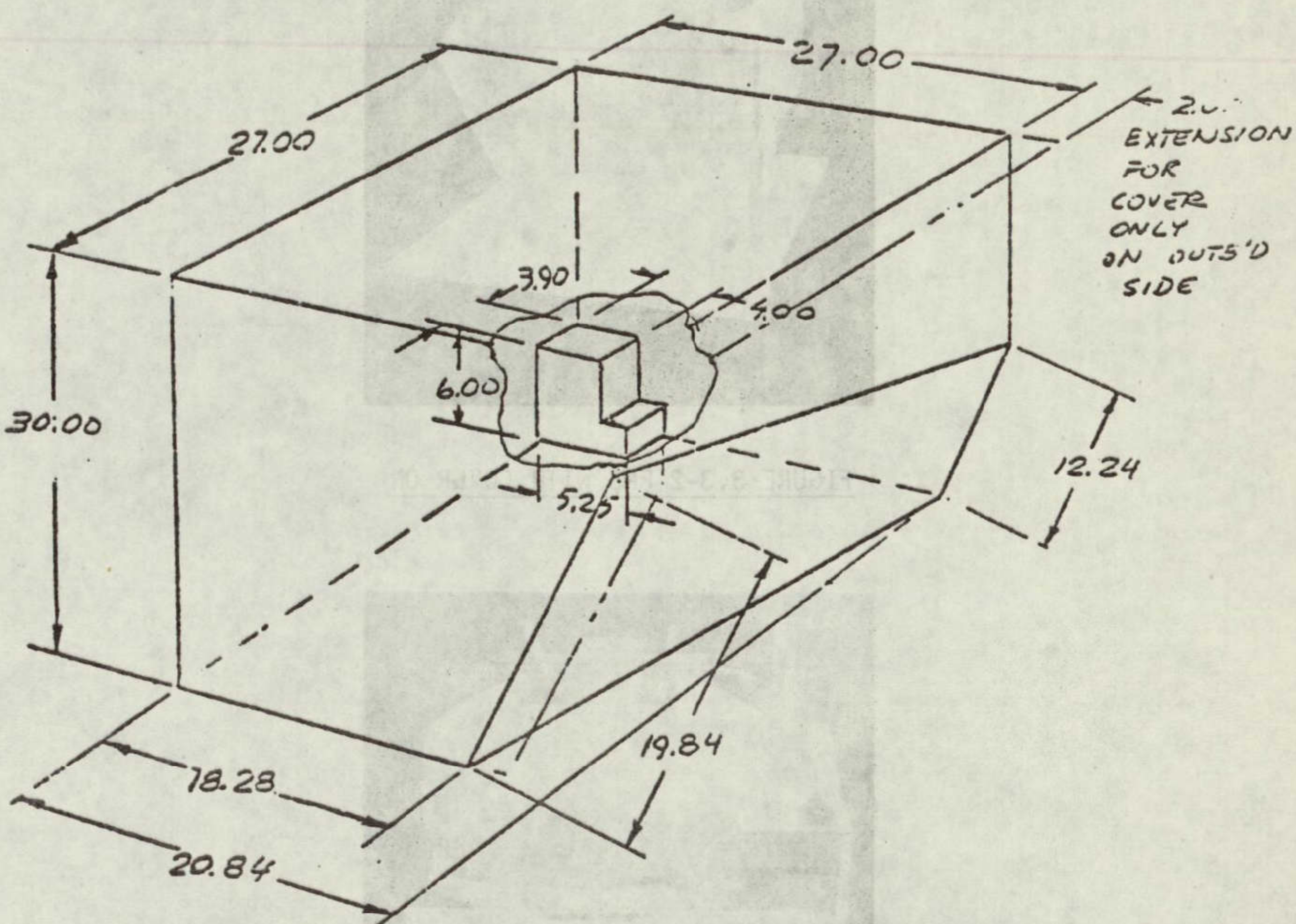

FIGURE 3.3-1 FMS ALLOWABLE ENVELOPE (SAME AS SHUTTLE WCS)

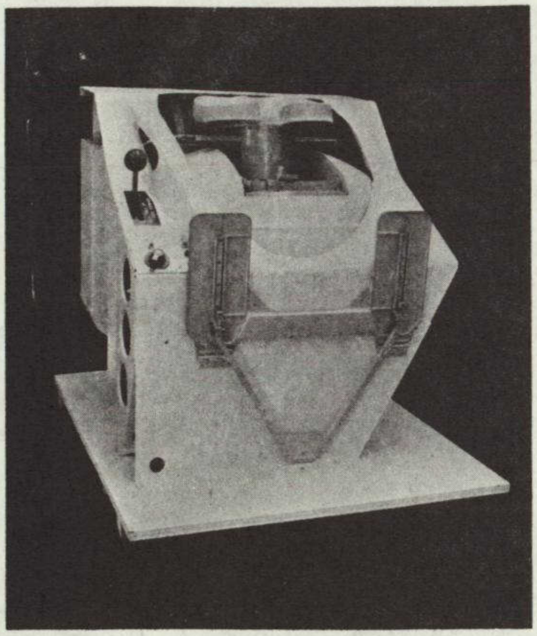

FIGURE 3.3-2 FMS WITH COVER ON

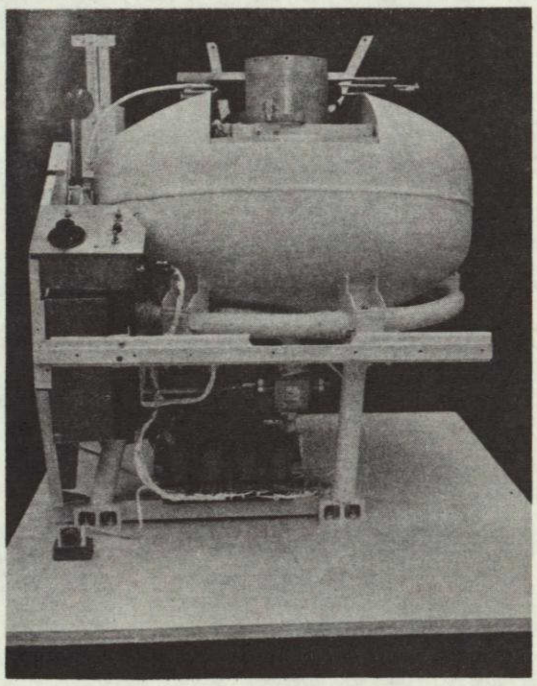

FIGURE 3.3-3 FMS WITH COVER OFF

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OF POOR QUALITY

Figures 3.3-4 and 3.3-5 show the left and right sides of the FMS. Figure 3.3-6 is a rear view of the structure support, power supplies and muffler/filter. Modular design concepts were employed in the design to enhance maintainability and repair. Drawings and a parts list for the FMS can be found in Appendix C. Modules or assemblies include:

- o Structure
- o Commode
- o Seat/Inertial Drive/Sampling
- o Power Supply
- o Slinger/Motor
- o Electronics/Control
- o Microcomputer

3.3.1 Structure Module

The FMS structure (Figure 3.3.1-1) is a tubular assembly having three (3) supporting legs and incorporating commode mounting plates and the system operating handle assembly. Provisions also include mountings for the electronics box, the control box, the microcomputer, the system blower and charcoal filter.

The FMS Structure is designed and arranged to be similar to the WCS structure.

3.3.2 Commode Module

The FMS Commode (Figure 3.3.2-1) is patterned after the WCS Commode Assembly and incorporates mounting provisions compatible with the WCS. A recess in the top surface of the assembly contains

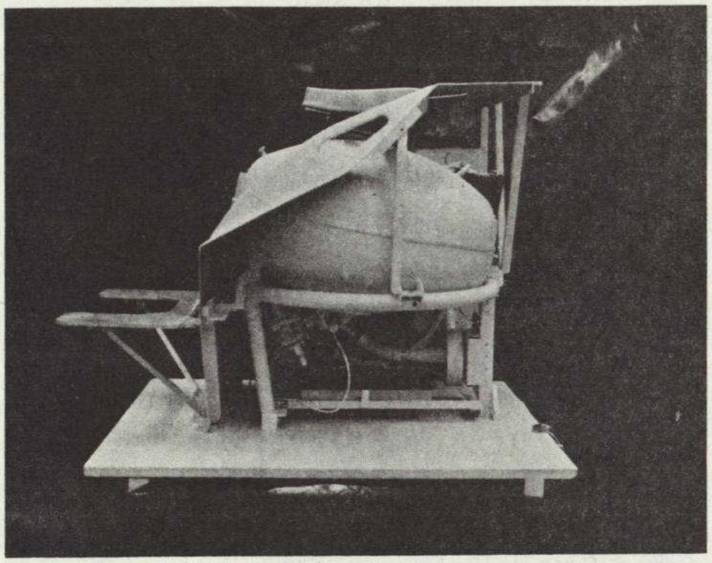

FIGURE 3.3-4 LEFT SIDE OF FMS

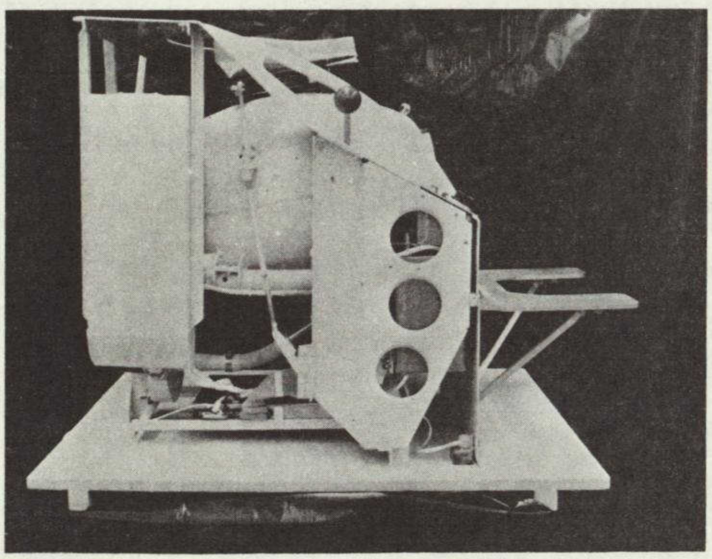

FIGURE 3.3-5 RIGHT SIDE OF FMS

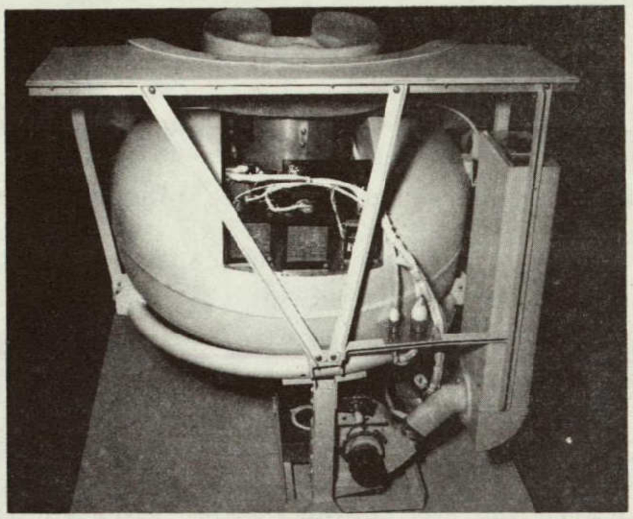

FIGURE 3.3-6 REAR VIEW OF FMS

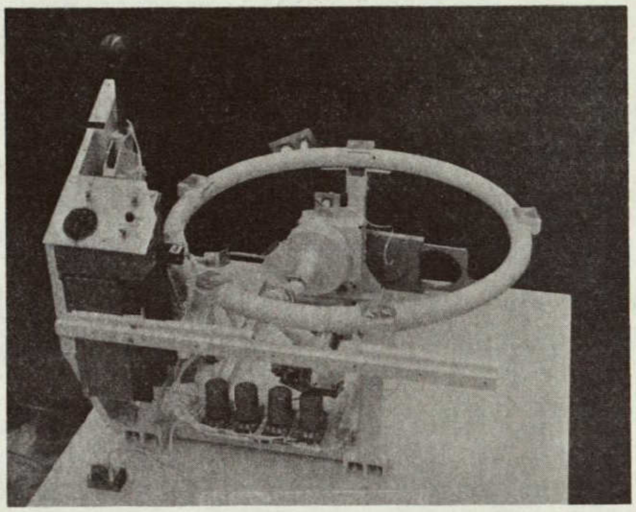

FIGURE 3.3.1-1 FMS STRUCTURE MODULE

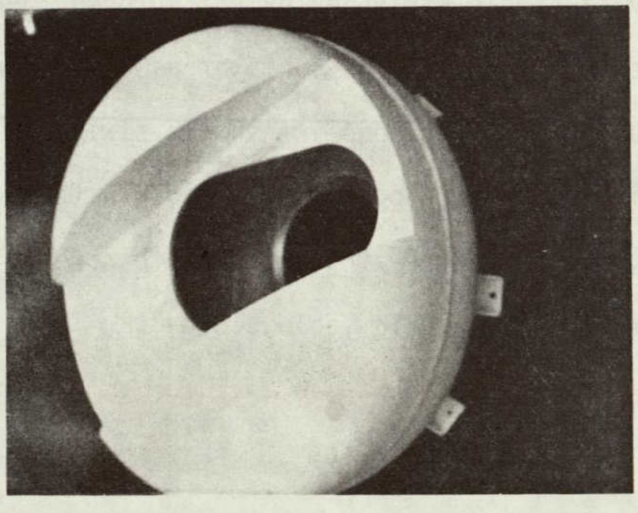

FIGURE 3.3.2-1 FMS COMMAND MODULE

provisions for mounting the Seat/Inertial Drive/Sampling module and the Power Supply module. The commode volume is designed to provide fecal storage capability for approximately 210 man days of operation.

3.3.3 Seat/Inertial Drive and Sampling Module (Figure 3.3.3-1)

The Seat/Inertial Drive Module provides the user interface with the FMS during system operation. The WCS type seat is designed to position the user over the slide valve port. The seat is attached to the Inertial Drive Assembly.

A motor driven lifting assembly is employed to slowly elevate the FMS seat (and user) for a distance of approximately two (2) inches. At the conclusion of this upward motion, the seat is released and snaps downward to its original position carrying the user with it. The resulting impact is intended to cause separation of the stool from the user.

Sampling in the FMS is accomplished through the use of the sampling assembly and a sample canister (Figure 3.3.3-2, and 3.3.3-3). The sampling assembly consists of a slide valve assembly, a sample strip deployment sprocket/gear assembly, and a sample strip guide. The canister assembly consists of an outer cover, a sample strip spool, a sample strip and removable handle. The canister is designed to be suitable with fecal sample storage methods, including freezing. Design features of the sample canister are outlined in Table 3.3.3-1.

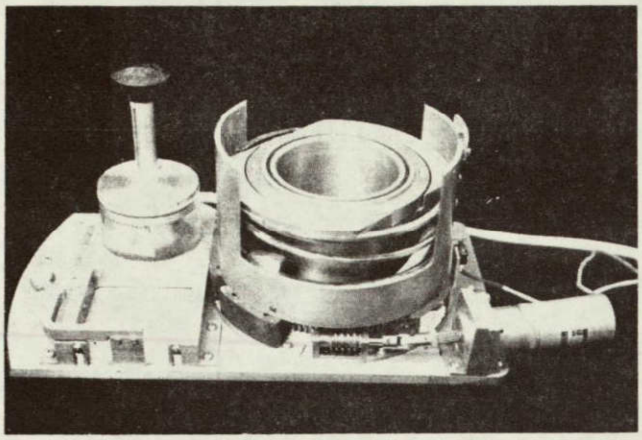

FIGURE 3.3.3-1
SEAT/INERTIAL DRIVE AND SAMPLING MODULE WITH SAMPLING CANISTER IN PLACE

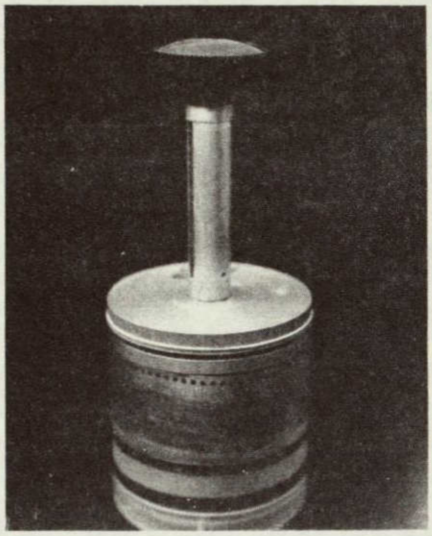

FIGURE 3.3.3-2 SAMPLE CANISTER

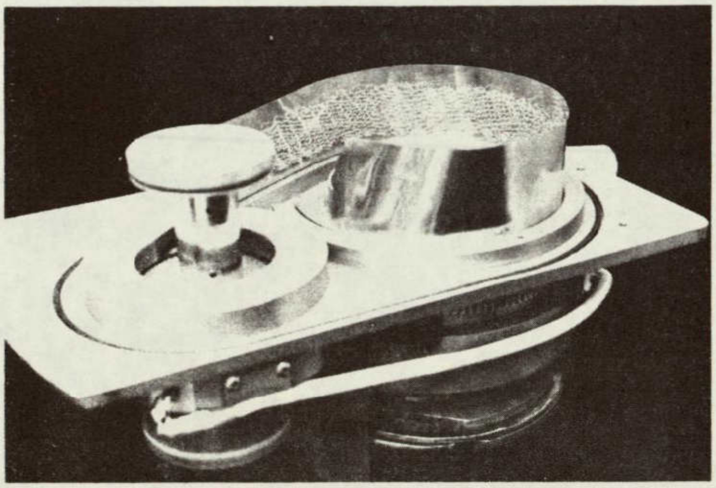

FIGURE 3.3.3-3
PARTIALLY ASSEMBLED SAMPLE MODULE SHOWING SAMPLE CANISTER WITH SAMPLING STRIP DEPLOYED

TABLE 3.3.3-1

SAMPLE CANISTER

DESIGN

DESIGN FEATURES

- o SAMPLE STRIP DEPLOYS WITH 2 TURNS OF CANISTER
- o CANISTER CANNOT BE REMOVED WITH SAMPLE SLIDE VALVE OPENED
- o SAMPLE SLIDE VALVE CANNOT BE OPENED WITHOUT CANISTER IN PLACE
- o OUTER CAN ENCLOSES SAMPLE TO MINIMIZE CONTAMINATION
- o CANISTER IDENTIFICATION
- o VOLUME - 19.4 IN^3 (318 cc)
- o SAMPLE STRIP LENGTH - 26.5"

3.3.4 Power Supply Module

The power supply module (Figure 3.3.4-1) contains the power supplies required for operation of the FMS. Using a 28VDC power source, this module provides the following:

VOLTAGE	PURPOSE
+5VDC	Digital Signal
-5VDC	Digital Signal
+34.6VDC	Servomotor Power
-34.6VDC	Servomotor Power
+12.3VDC	Sample Container ID
$\pm$15VDC	Servomotor Control

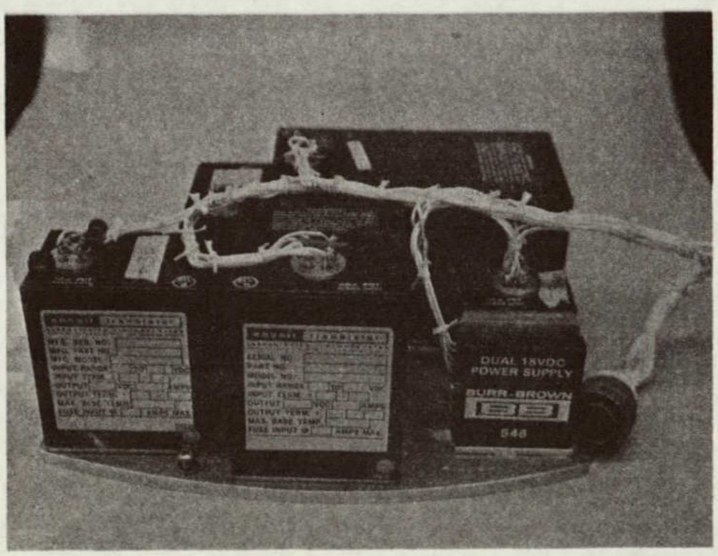

FIGURE 3.3.4-1 POWER SUPPLY MODULE

3.3.5 Slinger/Motor Module

This Slinger/Motor Module (Figure 3.3.5-1) consists of the Slinger motor and support, the slinger and the debris/bacteria filter. Access to the assembly is available through the top of the FMS by removing the Seat/Inertial Drive/Sampling Module or by removing the assembly through the bottom of the commode.

3.3.6 Electronics/Control Box Assemblies/Control Panel

The Electronics Box and the Control Box (Figure 3.3.6-1) are located at the left front of the FMS, and are accessible by removing the FMS cover. Figure 3.3.6-2 shows the control panel. The Electronics Box contains the analog signal processing electronics board for sensor motor control and mass measurement. A second board contains the electronics necessary for sample canister identification, signal conversion and provides the signal conditioning required for the microcomputer interface.

FMS switching including Power, User ID, Inertial Seat Drive and Slinger Stop are contained in the Control Box.

3.3.7 Microcomputer Module

The Slinger system measures mass of fecal material while in a one "G" or zero "G" condition by measuring the energy required to accelerate the sample mass up to a known speed. Figure 3.3.7-1 is a block diagram of the FMS mass measurement process. Figures 3.3.7-2 and 3.3.7-3 show the microcomputer module. The acceleration mechanism or slinger is a circular disk, along the periphery of which 30 tines are mounted vertically. In operation, the slinger is rotated at a speed of 2,500 RPM by a servomotor. The

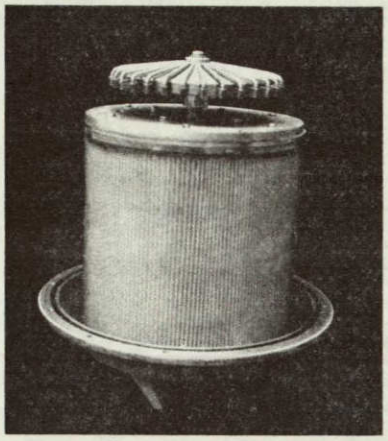

FIGURE 3.3.5-1 SLINGER/MOTOR MODULE

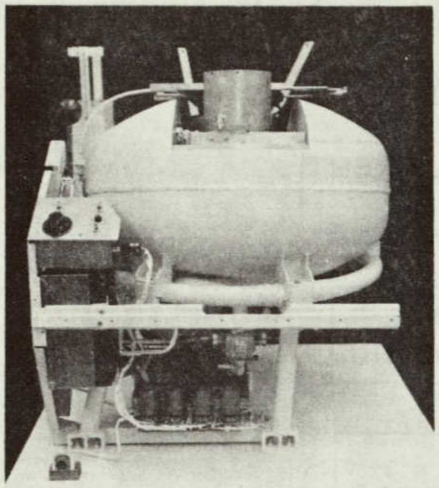

FIGURE 3.3.6-1 ELECTRONICS BOX AND CONTROL BOX

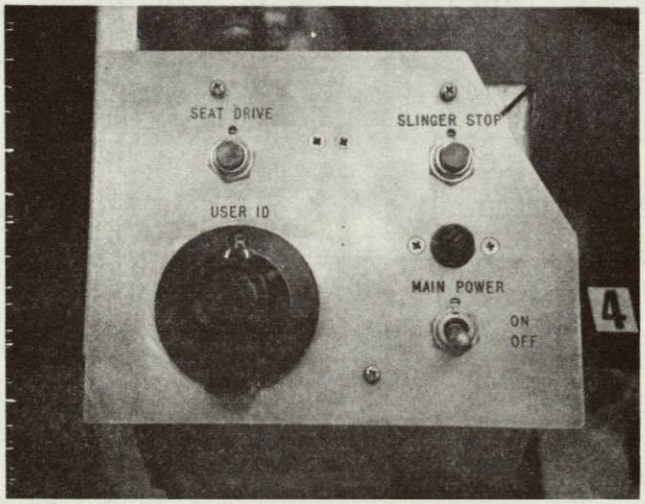

FIGURE 3.3.6-2 CONTROL PANEL

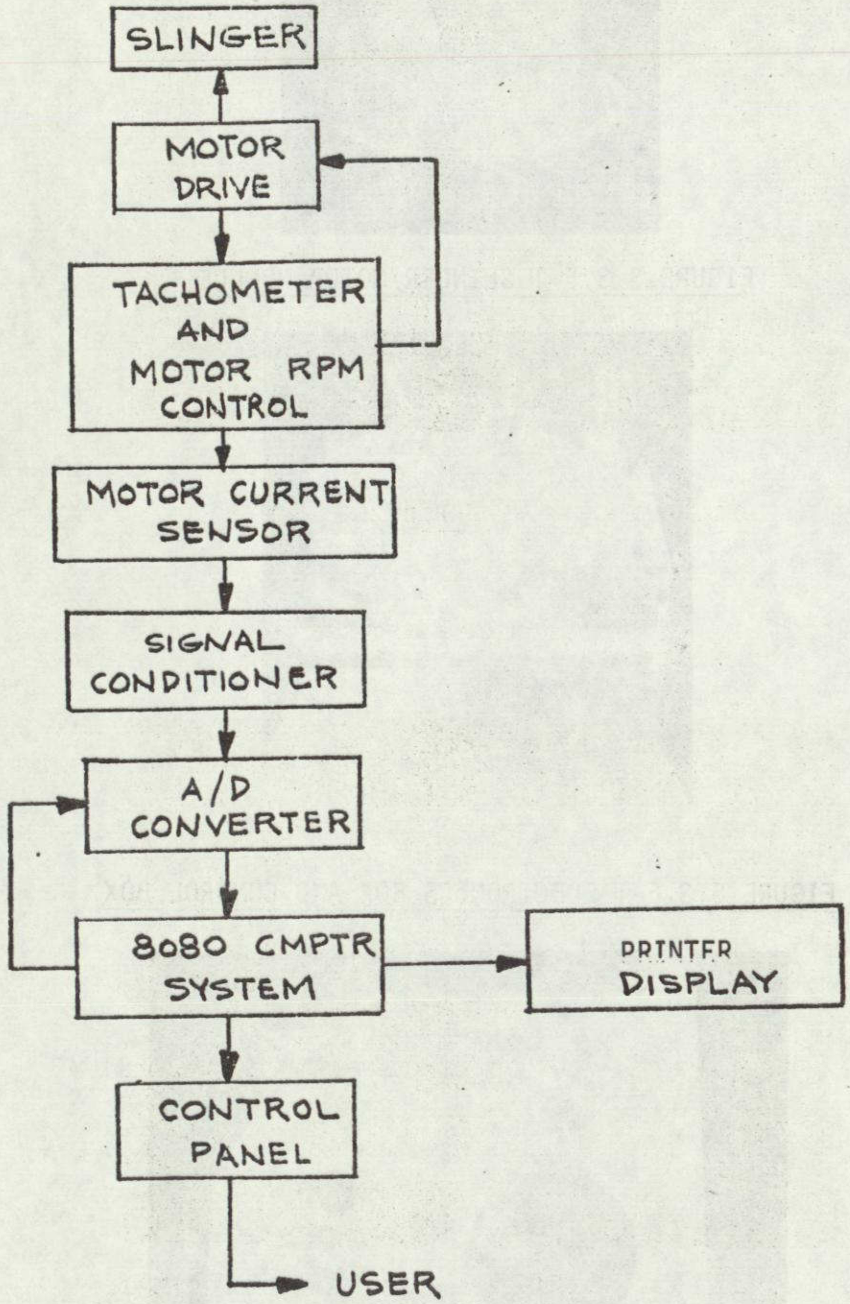

FIGURE 3.3.7-1 BLOCK DIAGRAM OF FMS MICROCOMPUTER MODULE

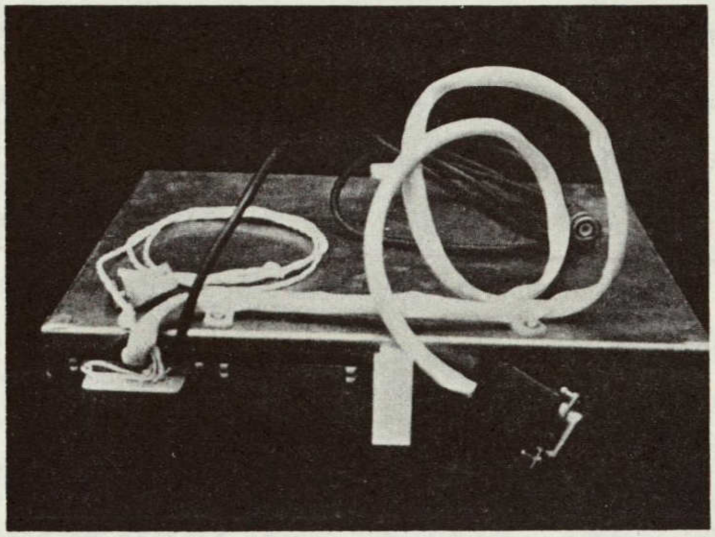

FIGURE 3.3.7-2 MICROCOMPUTER MODULE

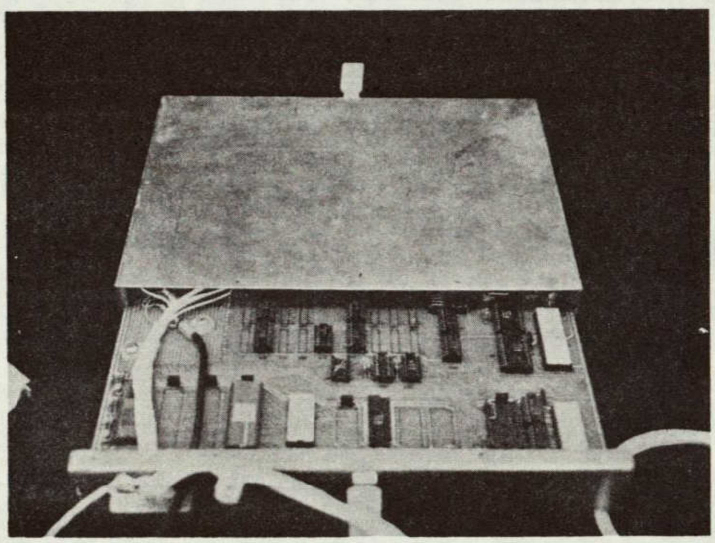

FIGURE 3.3.7-3 MICROCOMPUTER MODULE OPENED FOR ACCESS

sample mass is, upon being admitted to the system, drawn onto the slinger tines by an air stream. As the mass hits the tines, it is shredded and accelerated up to the speed of the disk, thrown away from the slinger disk, and collected in the commode which surrounds the disk. The slinger is kept at a constant speed by a servoloop comprised of an amplifier and a motor tachometer. When the motor is slowed by the sample, the current to the motor is increased to maintain velocity. This current change is sensed by a current sensing resistor which is in series with the motor armature. This motor power signal and the tachometer output voltage signal are introduced into the analog to digital converter (ADC) which is the analog input to the 8080 Microcomputer System. The Microcomputer calculates the area under the waveform during the period of interest, converts the resulting "counts" to "grams". At the completion of FMS use, the microcomputer transmits "SAMPLE MASS" data along with the "USER ID" and "SAMPLE ID" to the system printer which prints the information on hard copy.

Characteristics of the 8080 Computer System employed in the FMS are shown in Table 3.3.7-1.

4.0 TEST PROGRAM, INCLUDING HARDWARE MODIFICATIONS

4.1 Mass Measurement and Calibration

Evaluation of the FMS performance was based upon observed performance during a series of simulated fecal mass measurement tests In these tests, a simulated fecal material, comparable to feces in consistency, was mixed from "Gainsburger" dog food and Mazola Oil. Measured weight samples were admitted to the FMS in a manner to simulate the act of defecation.

The testing was conducted in several phases. During Phase I, which was conducted over an extended time period, 242 known weight samples were injected into the FMS and measured. Sample weights ranged from 25 to 400 grams. Operational limitations of the sample injections differed (e.g., no exact control of rate of injection or angle of injection) and the number of samples run at a specific weight value was not controlled.

As a result of variability noted in the collection of Phase I data, (e.g., intermittent data recording malfunctions, and apparent variability resulting from the time of day and operator) additional testing was conducted. Phase II tests consisted of injecting simulated fecal samples over the 25 to 400 gram range. A total of 10 samples was run for each weight (a total of 90 samples over the weight range) and additional care was taken to insure that the angle of injection and rate of injection was relatively constant and similar to that expected to occur during FMS use.

The results of Phase II testing revealed an apparent morning/afternoon cyclical effect on data as well as continuing occasional intermittent failure of data processing. Although the procedure for injection of samples was performed in a counter-balanced design to delineate the possible morning/afternoon effects, the variability and occasional reversals in the data indicated that statistical analysis would not be worthwhile.

Further evaluation of the hardware and microcomputer was conducted as a result of the Phase II testing. The evaluation resulted in modification to the Power Supply and microcomputer.

During the development testing of the FMS breadboard, a resistor in the servo-system electronics was changed from 0.047 ohms to 6.0 to limit or reduce the current to the slinger motor during a load change. The reduction in current to the motor during periods of load resulted in a "loosening" of the slinger motor servo control system. This loosening was characterized by a marked change in speed changes of the slinger when a load was applied. FMS mass measurement is based on the premise that the mass of the material is proportional to the energy change in the servo loop required to maintain the slinger at a fixed or constant speed. While a speed change correction factor had been incorporated in the FMS microcomputer algorythm when the FMS breadboard was built, it appeared possible that the factor might not adequately compensate for

the full effect of the speed change observed under this reduced current condition.

It was decided to perform an additional series of tests with the current to the servo system "unlimited." To accomplish this, the aforementioned 6 ohm resistor was replaced with a 0.1 ohm resistor. This change resulted in a "tighter" servo system; however, as a result of this change, the magnitude of the signal to the microcomputer was also reduced. An amplifier was constructed as shown in Figure 4.1-1 to compensate for this reduction to allow the microprocessor to function within its normal limits.

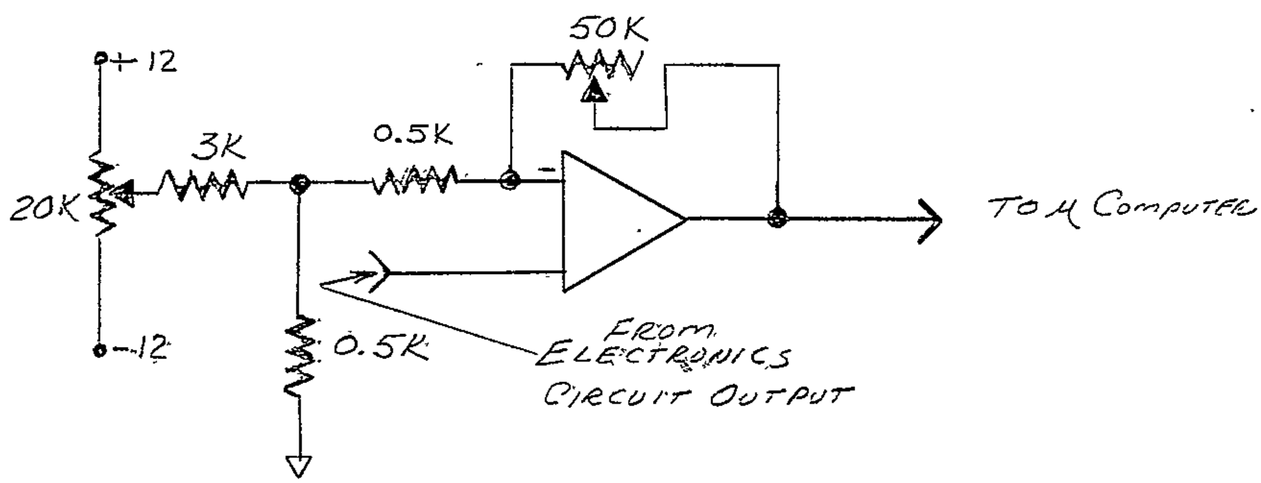

FIGURE 4.1-1 FMS AUXILIARY AMPLIFIER

This amplifier was used to increase the output signal level from the servo electronics.

Examination of the microcomputer revealed several loose connections associated with jumpers that were installed in the microcomputer. Movement of the loose connections was observed to cause intermittent data losses. The connections were corrected.

Upon completion of the resistor change, amplifier fabrication and test and microcomputer correction rework, a series of tests starting with a preliminary test and then a Phase III test was conducted. The preliminary tests were conducted in morning and afternoon time periods and used 150 gram samples. A total of 30 test injections were conducted. Phase III testing was performed comparably to Phase II testing. Simulated fecal masses of from 25 to 400 grams were injected into the FMS. Ten samples were injected at each of the weight classes used for a total of 90 samples. Following completion of the Phase III calibration, a series of 15 known weights were injected into the FMS. Five weights were used at approximately 50, 150 and 350 gram weight classes. The sample values obtained by FMS measurement were used to check FMS system accuracy by use of the linear regression calibration curve to predict sample mass.

4.2 Sampling

Sampling was performed as part of the mass measurement test. In this test, a sample canister was weighed and inserted in the FMS. A simulated fecal sample was then weighed and inputted to the FMS. Upon contacting the slinger, the simulated defecation was shredded and

thrown outward in the normal manner. The simulated defecation was retained on the sample strip. The slinger was stopped, the sample strip was retracted and the sample canister removed and reweighed. The weight relationship between the simulated fecal input and the collected sample was calculated.

5.0 RESULTS/DISCUSSIONS

5.1 Mass Measurement and Calibration

The data and methods used for analyses for performance of mass measurement and calibration of the FMS can be found in Appendix D. Methods used for data analysis have included linear regression curve fitting and description statistics.

5.1.1 Phase I - Extended Testing

Summaries of the results and data plots of Phase I power limited testing for the 242 simulated fecal samples that were introduced into the UMS can be found in Table 5.1.1-1. Figure 5.1.1-1 shows the calculated mass values for the simulated fecal input weights for the Phase I testing. Figure 5.1.1-2 shows the error values (deviation from input weight) as a function of simulated fecal input weights.

The summary Table 5.1.1-1 shows a standard deviation of error scores of approximately nine percent. This deviation score is for all sample points across the 25 to 400 gram weight range tested. All data has been included, regardless of some variables introduced by operational procedures or potential equipment malfunction. Figure 5.1.1-1 is an illustration of the spread of the calculated mass showing the linearity of the calculated values versus the input weights. Figure 5.1.1-2 shows the spread of the error scores for the input weights. Note that the error scores are relatively large and evenly spread throughout the data.

TABLE 5.1.1-1 SUMMARY VALUES FOR ERROR SCORE FOR PHASE I TESTING

	MAXIMUM LIKELIHOOD ESTIMATES FOR POPULATION PARAMETERS	UNBIASED ESTIMATES FOR POPULATION PARAMETERS
ARITHMETIC MEAN:	-1.7400	-1.7400
STANDARD DEVIATION:	8.9980	9.0166
VARIANCE:	80.964	81.300
NUMBER OF VALUES:	242	

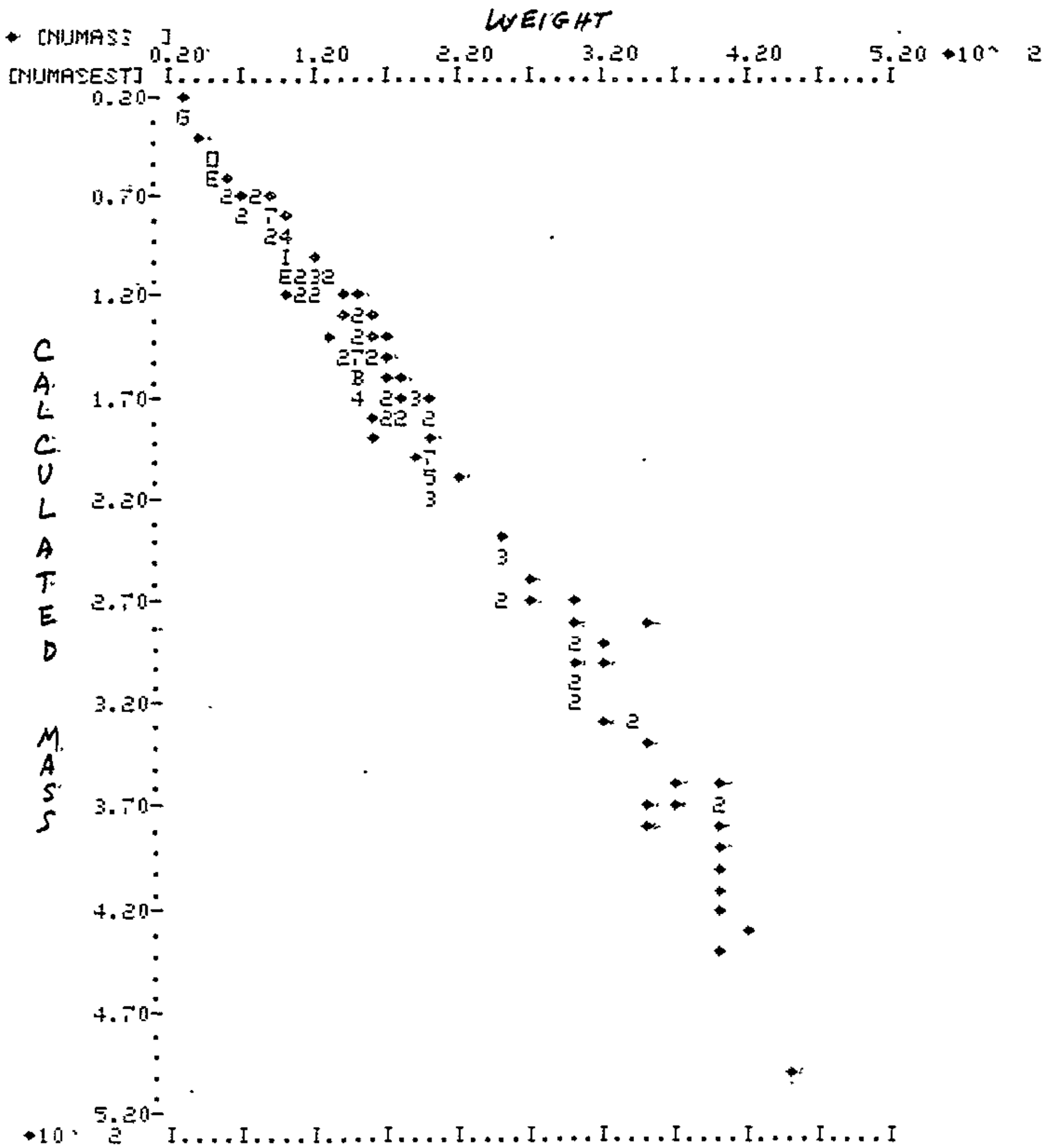

FIGURE 5.1.1-1
CALCULATED MASS AS A FUNCTION OF INPUT WEIGHT FOR PHASE I TESTING

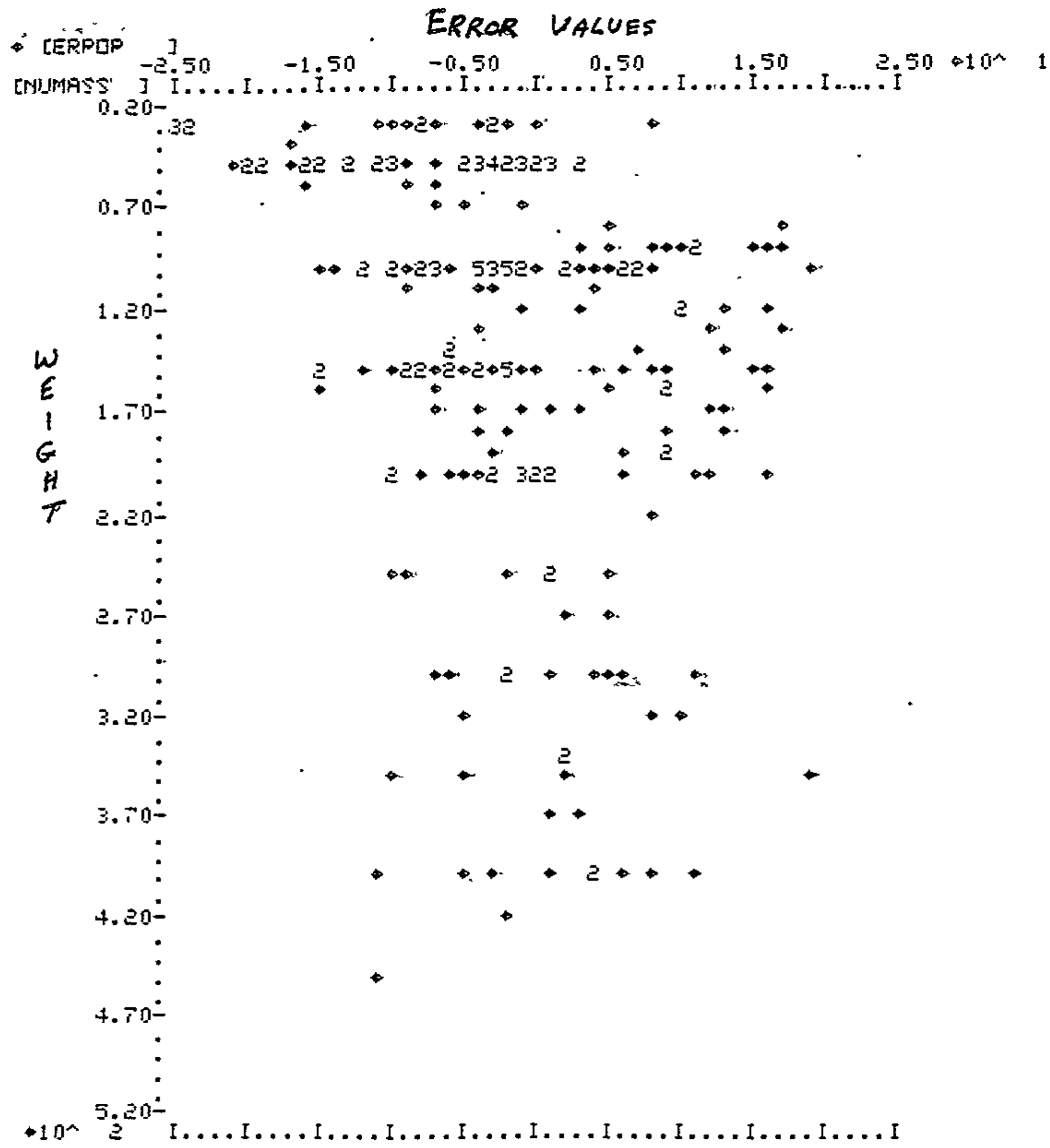

FIGURE 5.1.1-2
ERROR VALUES AS A FUNCTION OF SIMULATED FECAL INPUT WEIGHTS FOR PHASE I TESTING

5.1.2 Phase II Testing

Summaries of the results and data plots for Phase II power limited tests are shown in Table 5.1.2-1 and Figures 5.1.2-1 and 5.1.2-2. Figure 5.1.2-1 shows the calculated mass values for the simulated fecal input weights for the Phase II testing. Figure 5.1.2-2 shows the error values as a function of simulated fecal input weights.

The Summary Table 5.1.2-1 shows that for the total population of 90 scores in the limited power mode Phase II testing, there was a standard deviation of the error score of approximately 13.6%. This data had marked variability between morning and afternoon sessions which was unexplained. Evaluation of the data, however, indicated that a major portion of the error was being caused by the 25 and 50 gram weight classes. The lower portion of Table 5.1.2-1 shows the effect of removing the 25 and 50 gram scores from the data. The standard deviation score was reduced to approximately 8.7%. The large errors found at the low end of the weight classes may be due to the specific algorythm and threshold values used in the microcomputer. Figure 5.1.2-1 is an illustration of the spread of the calculated mass showing the linearity of the calculated weights versus the input weight. Figure 5.1.2-2 shows the spread of the error scores for the input weights. Note the very wide spread of errors at low masses with decreasing values at higher masses.

TABLE 5.1.2-1

SUMMARY VALUES FOR PHASE II TESTING INCLUDING 90 AND 70 SAMPLE POPULATION

	MAXIMUM LIKELIHOOD ESTIMATES FOR POPULATION PARAMETERS	UNBIASED ESTIMATES FOR POPULATION PARAMETERS
ARITHMETIC MEAN:	-0.15918	-0.15918
STANDARD DEVIATION:	→ 13.564	13.640
VARIANCE:	183.98	186.04
NUMBER OF VALUES:	$\boxed{90}$	

25 THROUGH 400 GRAM SAMPLES

	MAXIMUM LIKELIHOOD ESTIMATES FOR POPULATION PARAMETERS	UNBIASED ESTIMATES FOR POPULATION PARAMETERS
ARITHMETIC MEAN:	-0.96815	-0.96815
STANDARD DEVIATION:	→ 8.7363	8.7994
VARIANCE:	76.323	77.429
NUMBER OF VALUES:	$\boxed{70}$	

(MINUS 25 AND 50 GRAM SAMPLES)

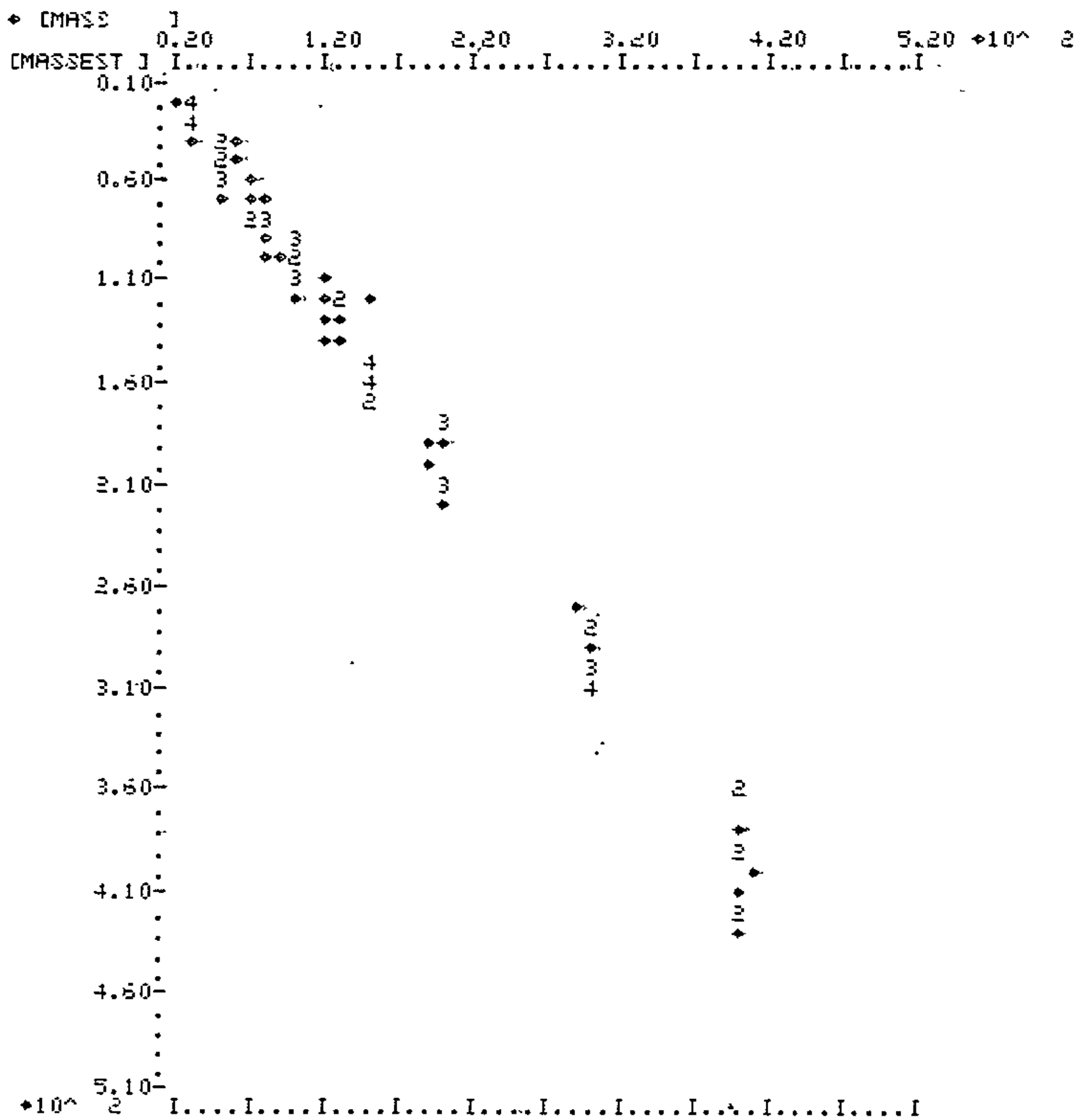

FIGURE 5.1.2-1
<u>CALCULATED MASS AS A FUNCTION OF INPUT WEIGHTS FOR PHASE II TESTING</u>

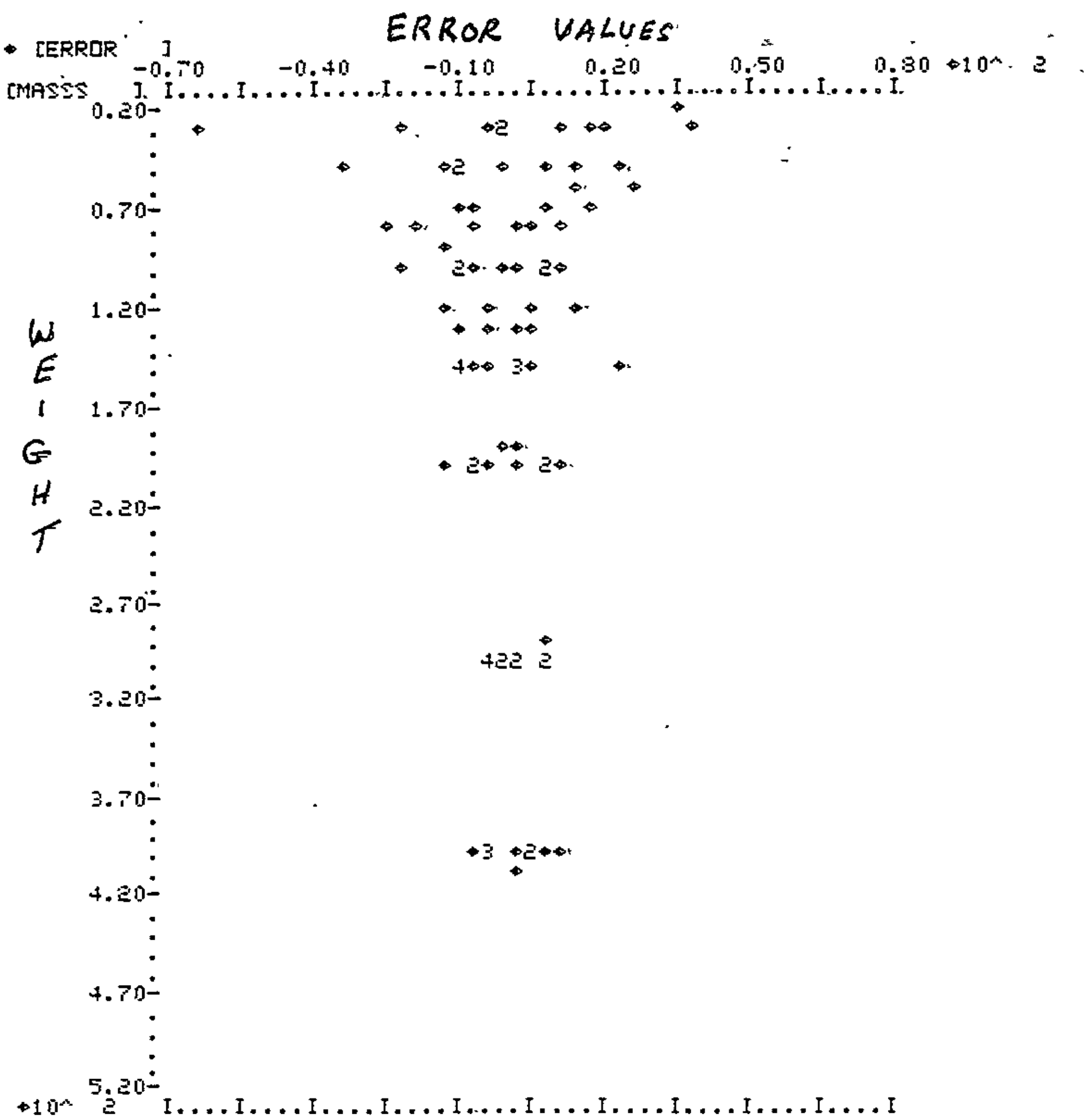

FIGURE 5.1.2-2
ERROR SCORES AS A FUNCTION OF SIMULATED FECAL INPUT WEIGHTS FOR PHASE II TESTING

5.1.3 Phase III Testing

Because of the variability found in the Phase I and II testing, additional hardware and microcomputer evaluations were performed. As indicated in Section 4.1, modifications to power (power limitations to the servomotor removed) and the microcomputer (corrections of loose/intermittent connections) were implemented and the test rerun in basically the same fashion as in Phase II.

Phase III initial tests consisted of rerunning thirty 150 gram samples in morning and afternoon sessions. Data analysis indicated no differences between morning and afternoon session. The mean values of unconverted raw count scores for morning session was 112.3, and the mean value of uncorrected raw count scores for the afternoon session was 112.7. Further, the overall 1 standard deviation score for the raw count data was a low 2.9%. This low value of variability may be in part due to the fact that in all other testing inputs sample size was randomized whereas in this sequence, all samples were 150 gram samples in succession with no intervening different weight samples.

Phase III unlimited power testing was then continued. Summaries of the results are shown in Table 5.1.3-1. The variability of the scores, similar to Phase II results, is shown to be reduced significantly by removing the 25 and 50 gram samples. The standard deviation score for the 90 sample analysis was 8.3% while the standard deviation for the 70 sample analysis was 6.5%.

TABLE 5.1.3-1

SUMMARY VALUES FOR PHASE III TESTING INCLUDING 90 AND 70 SAMPLE POPULATIONS

	MAXIMUM LIKELIHOOD ESTIMATES FOR POPULATION PARAMETERS	UNBIASED ESTIMATES FOR POPULATION PARAMETERS
ARITHMETIC MEAN:	-1.9166	-1.9166
STANDARD DEVIATION:	8.2699	8.3162
VARIANCE:	68.391	69.159
NUMBER OF VALUES:	$\boxed{90}$	

25 through 400 gram Samples.

	MAXIMUM LIKELIHOOD ESTIMATES FOR POPULATION PARAMETERS	UNBIASED ESTIMATES FOR POPULATION PARAMETERS
ARITHMETIC MEAN:	-0.82173	-0.82173
STANDARD DEVIATION:	6.5102	6.5572
VARIANCE:	42.383	42.997
NUMBER OF VALUES:	$\boxed{70}$	

(minus 25 and 50 gram sample weights)

Figure 5.1.3-1 shows the calculated mass as a function of input weight and illustrates the linearity and spread of the data. Figure 5.1.3-1 shows the calculated mass as a function of input weight for the 90 samples of Phase III testing. Note the linearity and spread of the data. Figures 5.1.3-2 and 5.1.2-3 show the error scores versus input weight for the 90 and 70 sample analyses, respectively. The 70 sample population has reduced error values and variability.

After examination of the data and regression analyses, consideration was given to the possibility of using a microprocessor on the FMS to give an "exact" fit to the calibration data as opposed to the assuming that the relationship between weight inputs and measured estimated masses was linear. To obtain an approximation of what such a data fitting technique might do to error variability, the data from the Phase III power unlimited tests was blocked in groups according to the specific weights inputted. Nine blocks of data were available with 10 data points for each of the weight classes which ranged from 25 to 400 grams. Table 5.1.3-2 shows the results of the calculation for standard deviation error scores for the grouped by input weight data for Phase III testing. The overall average standard deviation error value for all weight groups is 7.77%. Elimination of the two lowest groups (25 and 50 grams) reduces the average standard deviation value to 6.54%. Thus, a better fitting calibration curve should

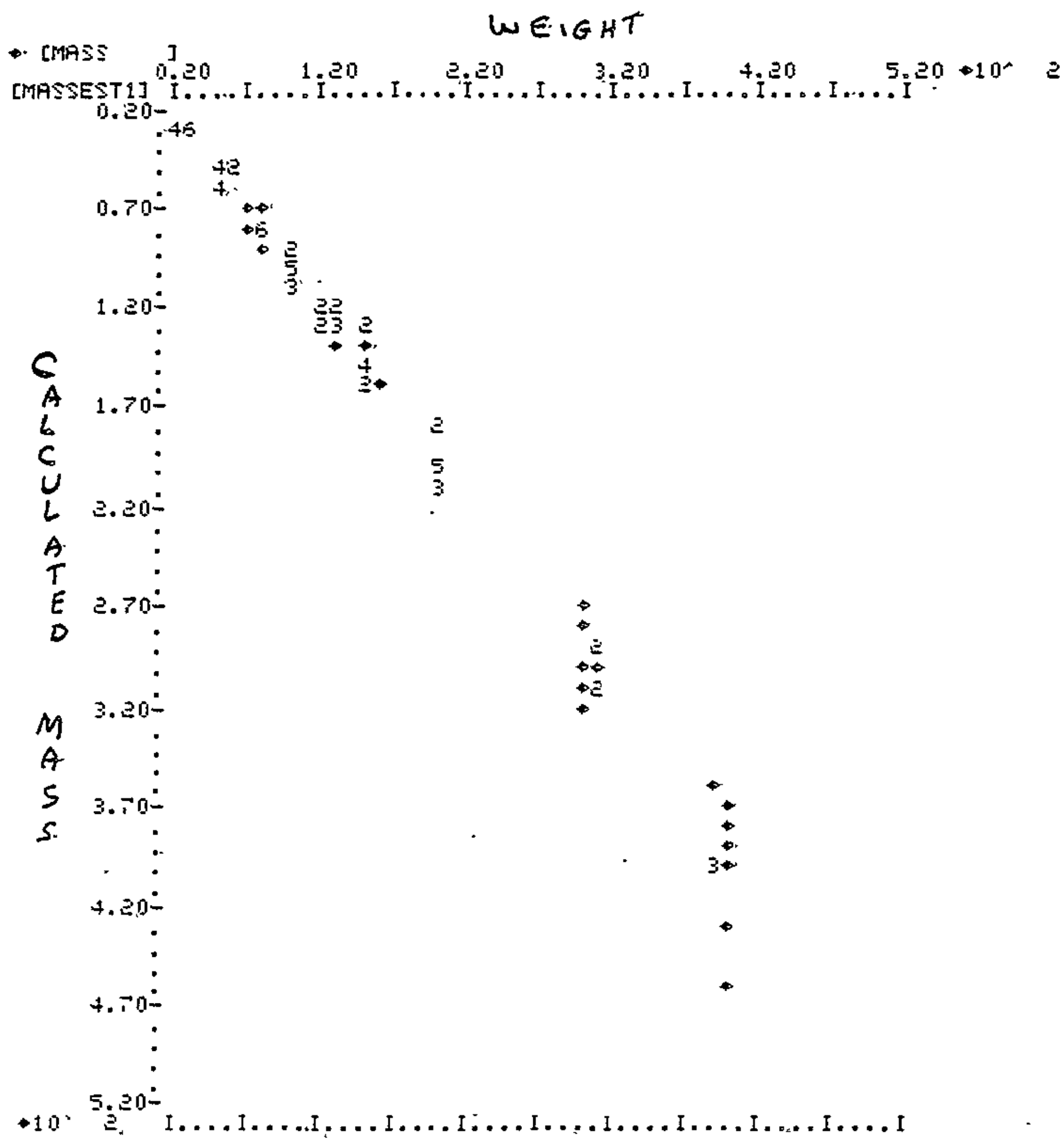

FIGURE 5.1.3-1
CALCULATED MASS AS A FUNCTION OF INPUT WEIGHT FOR PHASE III TESTING

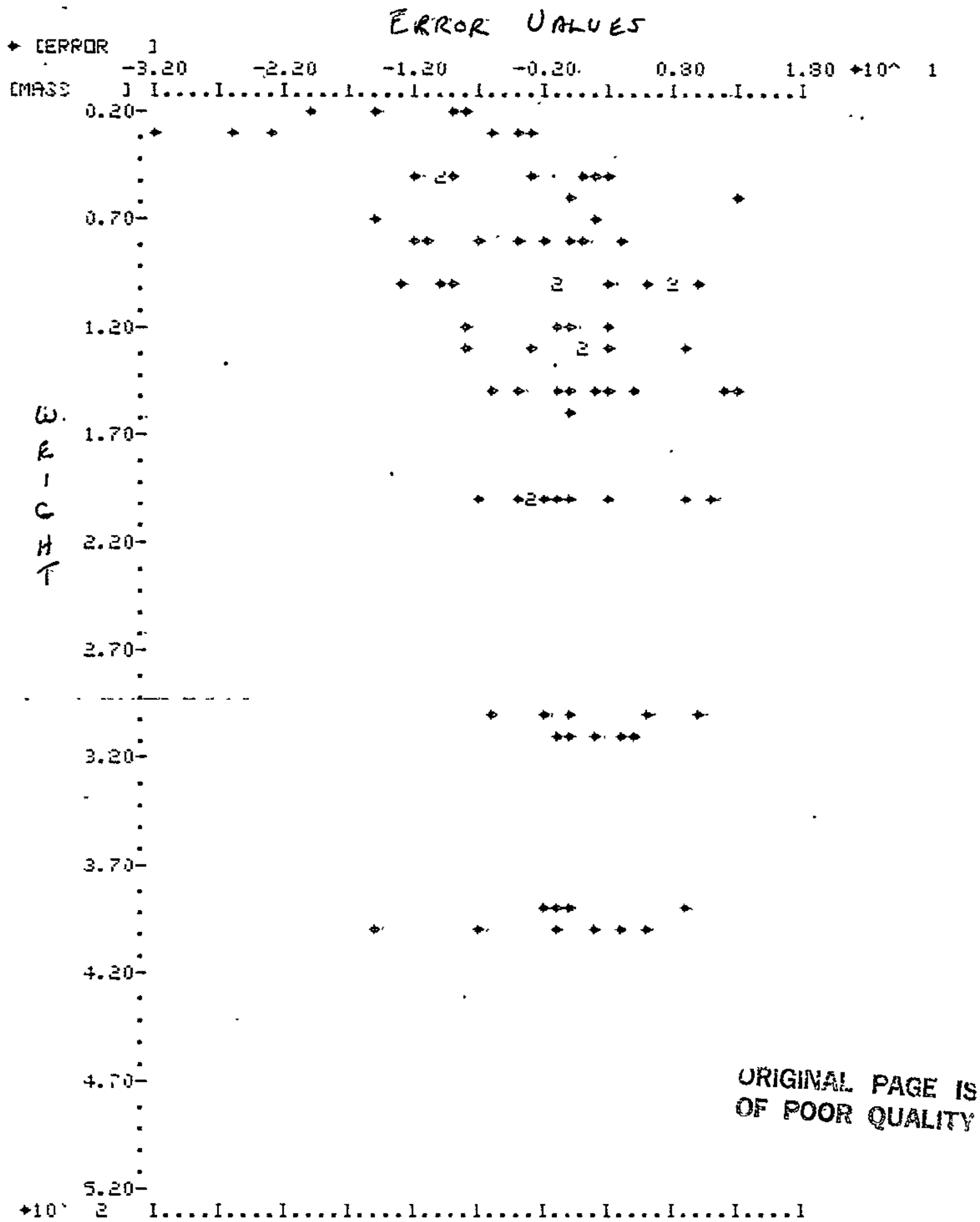

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FIGURE 5.1.3-2
ERROR VALUES AS A FUNCTION OF SIMULATED FECAL INPUT FOR 25 THROUGH 400 GRAM INPUTS FOR PHASE III TESTING

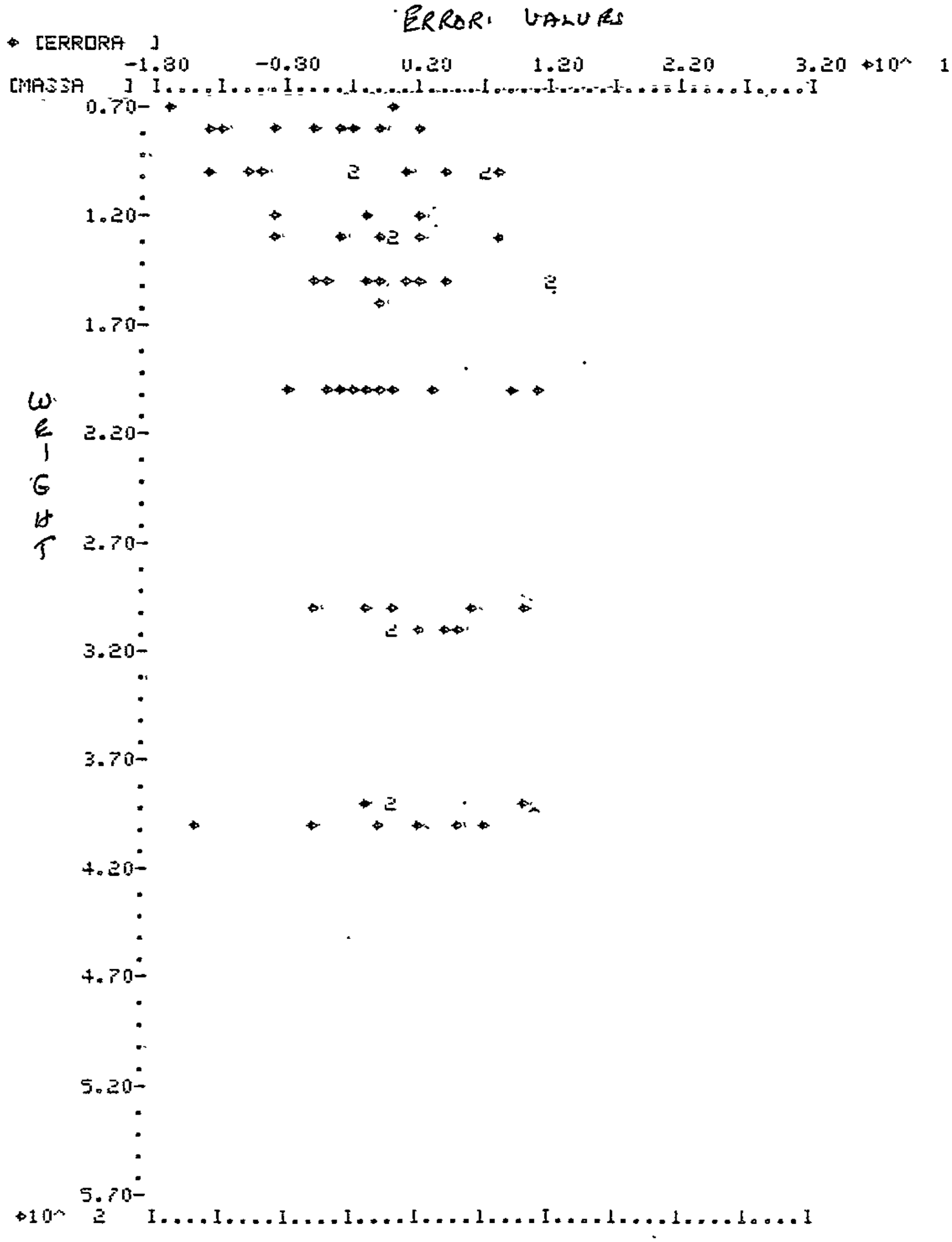

FIGURE 5.1.3-3
ERROR VALUES AS A FUNCTION OF SIMULATED FECAL INPUTS FOR
75 THROUGH 400 GRAM INPUTS FOR PHASE III TESTING

TABLE 5.1.3-2

STANDARD DEVIATION OF CALCULATED ERROR SCORES FOR PHASE III UNLIMITED POWER DATA[1]

SAMPLE WEIGHT GROUP	STANDARD DEVIATION OF CALCULATED ERRORS
25	14.94
50	9.20
75	6.97
100	9.00
125	5.37
150	6.59
200	5.79
300	5.06
400	7.06

[1] Data for these analyses can be found in Appendix D.

result in a lower calculated error value (increased accuracy of measurement) than the use of a linear regression approach. Further, as was also seen in previous data analyses, the largest source of error results from the very small sample size groups. These results suggest the incorporation of a microprocessor in the FMS which reflects the exact shape of the calibrated curve and concentration in reducing errors at small sample sizes.

Following completion of the Phase III calibration/error curve testing, fifteen samples of known weight were injected into the FMS. Five samples were injected at approximately 50, 150 and 350 weight values. The resulting FMS output data was treated as though the weight values were unknown. The FMS output for each of the "unknowns" was projected to a mass value using the linear regression curve developed from the Phase III calibration data. Each resulting value was compared to the actual input weight and a percentage accuracy score was calculated. Figure 5.1.3-4 shows the resulting distribution of values. At fifty grams, the range of error was from -29% to +2%. At 150 grams, the error range was from -6% to +4%, while at 350 grams, the error range was from -8% to +5%. Note that the values are negatively skewed. With additional correction, for this shift, the accuracy range would have been $\pm$15.5%, $\pm$5% and $\pm$6.5% for the 50, 150 and 350 gram weight classes respectively. Additional reduction in these error scores could have been accomplished if specific calibration curve fittings had been part of the microcomputer rather than using a best fit linear regression.

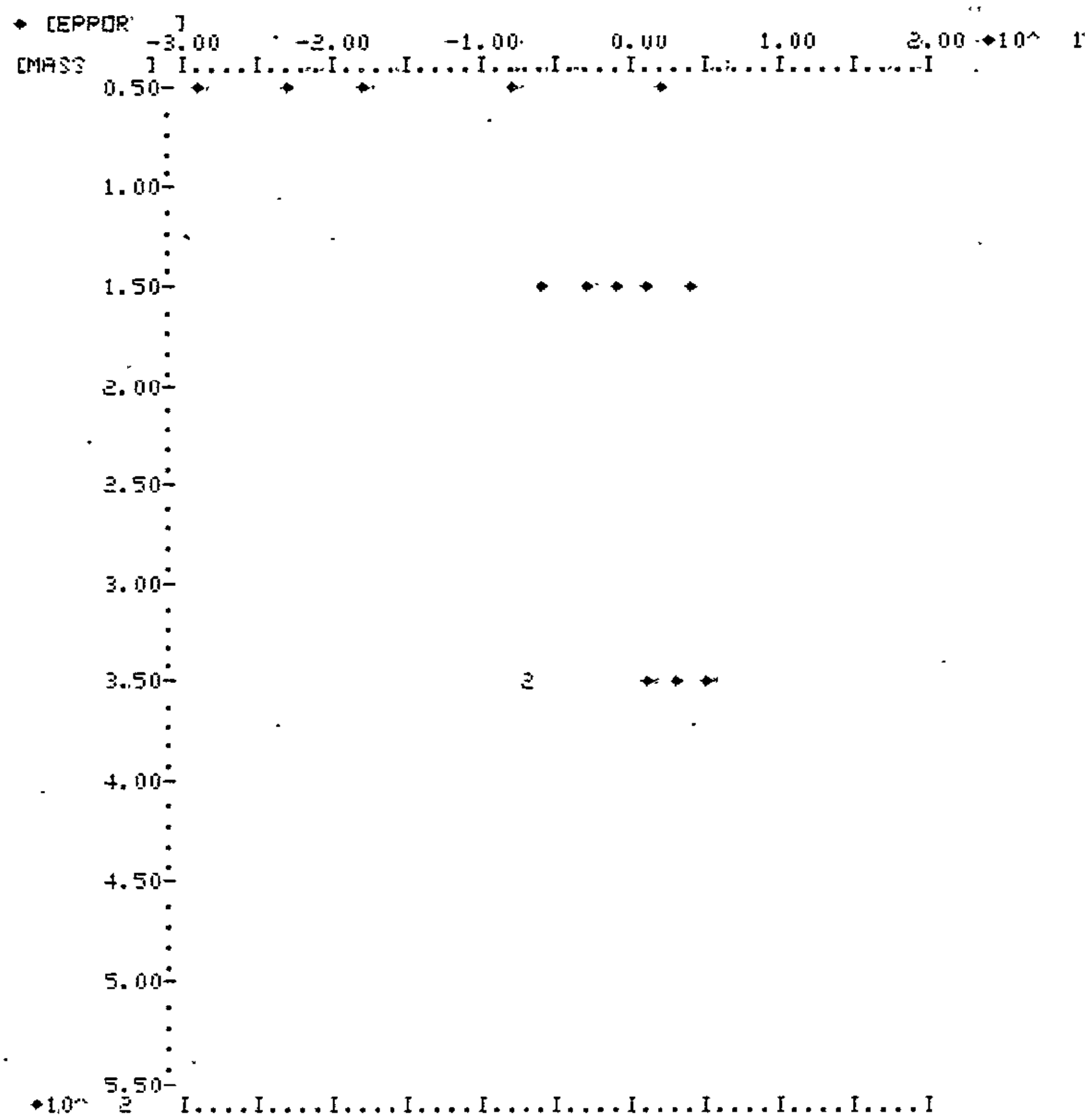

FIGURE 5.1.3-4
RANGE OF MEASUREMENT ACCURACY OBTAINED FROM THE PHASE III
UNKNOWN SAMPLE WEIGHT MEASUREMENT TEST

5.2 Sampling

A wide variation was observed in the samples collected. During the sampling testing, for example, with two-hundred gram input, the sample sizes varied from approximately 50 to 150 grams. However, it was observed that the collected samples were distributed in a relatively uniform layer on the sample strip.

The design of the sampling strip/canister/track provides that the sample strip be formed to assure proper engagement with the sample strip deployment sprocket. When properly formed in this manner, the sample strip deployment and retraction were positive and the operation was smooth.

5.3 Inertial Collector

Performance of the inertial collector is partially gravity dependent. In a one "g" environment, the inertial seat drive motor is required to raise the full weight of the user while compressing the return spring. In zero "g", the motor will only drive against the load of the return spring since the user will be weightless. The FMS drive system is based on a compromise. To maintain a package size compatible with the FMS design, the drive motor is designed to raise a load of 175 pounds against the spring force. For weights in excess of this, it is necessary for the user to assist the mechanism by pushing himself up via the FMS handles.

Cycle time for the inertial seat drive operation is approximately ten seconds. During this time, the seat is raised through a distance

of approximately 2.0 inches after which it is driven downward sharply by the compression load on the return spring, and in one "g" by the weight of the user, and impacts four rubber bumper pads positioned around the inertial drive mechanism. Impact resulted in a sharp, loud report type sound which will require additional design effort to reduce the noise to a more acceptable level.

Extensive testing of the inertial seat was not performed due to the effects of one "g" on the system, and the lack of zero "g" effects on stool separation. Zero "g" flights are required to further evaluate this system.

6.0 CONCLUSIONS/RECOMMENDATIONS

6.1 Conclusions

6.1.1 Mass Measurement

This report has described a series of tests on the FMS where significant performance improvement In actual fecal mass measurement has been demonstrated. Initial accuracy measurements (one standard deviation scores) at the outset of this effort were as high as ±9%. Improvements in analysis methods and hardware and microcomputer modifications have resulted in a reduction of measurement error to ±7.7% over the range of simulated fecal weights systematically tested (25 to 400 grams). Further testing of the FMS after calibration showed actual ranges of accuracy of ±5% for nominal weight stools (150 grams).

Generally consistent throughout all testing was the phenomena that the poorest accuracies were found at low simulated stool values (25 and 50 grams); accuracy was markedly improved by elimination of these data points from the analyses. Examination of possible causes for this relatively large error at low mass values included: Threshold sensitivity of the microcomputer which adversely affects FMS data at low weight values; Differences in the microprocessor with respect to the number of significant digits used for calculation at low and high mass values; and, The mathematical methods for calculating estimated masses as performed by the microcomputer.

Operational conditions such as the angle of contact of the stool with the slinger, and the rate of movement of the stool at contact with the slinger may also have significant effect on accuracy of measurement. Some aspects of these variables might be better controlled in a zero "g" environment with controlled air flow where better control of stool movement and position might be achieved.

Considering all the operational parameters impacting the measurement of a fecal mass in the FMS, the goal of a measurement accuracy of $\pm 2\%$ may be difficult, but not impossible to accomplish. Accuracy on the order of $\pm 5\%$ should be relatively easy to accomplish with further refinement of the existing FMS. Review of requirements for clinical and medical research test data of the type anticipated for the FMS suggests that accuracy of $\pm 5\%$ may be sufficient. Further consideration of the measurement accuracy requirement would be helpful in determining the course of further FMS development.

The FMS, with refinements, has the feasibility of measuring fecal mass and of obtaining fecal samples without excessive time consumption, handling problems and other inherent difficulties of bag type systems.

6.1.2 Sampling System and Inertial Seat

The sampling system was demonstrated to function approximately in a one "g" environment. The inertial seat, for fecal separation, functioned according to design but within the

basic limitations of a one "g" demonstration system. Both the sampling system and the inertial seat require zero "g" testing in Keplarian Flight for complete testing of their performance.

6.2 Recommendations

The FMS concept has been sufficiently developed to overcome development problems; however, several refinements are required before complete flight measurement accuracy and user acceptability will be fully achieved. These include:

- The microcomputer integration with the specific slinger design and the servo-motor must be optimized. System signal to noise ratio, threshold truncation and data manipulation must be better understood for solid fecal mass estimation. Calibration of the FMS should be provided by a ROM in the microprocessor to provide a specific curve for mass estimates rather than a linear regression or constant conversion.
- Long term users tests must be completed to assess system acceptability and durability.
- Zero "g" aircraft tests with known sample sizes are needed to calibrate the FMS and measure the accuracy of mass measurement in a zero "g" environment. Evaluations in zero "g" should also assess performance of the sampling mechanism and the inertial seat of the FMS.

Phased refinement of the FMS is recommended starting with the microprocessor and design improvements followed by the long term ground based testing and ending with the zero "g" tests. This approach will provide assurance of zero "g" functional FMS which will meet the flight crew requirements while satisfying the needs of medical investigators requiring FMS capabilities.

APPENDIX A

FMS ENGINEERING MODEL

PERFORMANCE SPECIFICATION

GENERAL ELECTRIC
SPACE DIVISION
PHILADELPHIA

PROGRAM INFORMATION REQUEST / RELEASE

PIR NO.	*CLASS. LTR.	OPERATION	PROGRAM	SEQUENCE NO.	REV. LTR.
		1R60	77	130	A

*USE "C" FOR CLASSIFIED AND "U" FOR UNCLASSIFIED

FROM		TO	
G. L. Fogal		File	
DATE SENT	**DATE INFO. REQUIRED**	**PROJECT AND REQ. NO.**	**REFERENCE DIR. NO.**
7/19/77			

SUBJECT

FMS Engineering Model Performance Specification

INFORMATION REQUESTED/RELEASED

The following performance specification for the FMS supercedes the draft dated April 1977 and reflects the results of the PDR. This revised specification shall be used to guide the detail design of the FMS engineering model.

1.0 SCOPE

This specification defines the performance and design requirements for one engineering model Feces Monitoring System (FMS). The engineering model FMS shall be used to support life science diagnostic and medical experiments related to simulated SHUTTLE missions. The FMS shall support this activity thru the automatic collection; real time mass measurement and sampling of individual defecations.

1.1 Purpose

The purpose of the engineering model FMS shall be to provide design verification of an equipment assembly applicable to the SHUTTLE program.

2.0 APPLICABLE DOCUMENTS

Statement of work, Contract NAS 9-15159.

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3.0 REQUIREMENTS

3.1 Performance

cc: R. W. Murray, Mgr.
E. J. Glanfield
G. L. Fogal (4)
A. C. Andersen
R. A. Sergo

PAGE NO. 1 OF 24

RETENTION REQUIREMENTS

COPIES FOR	MASTERS FOR
☐ 1 MO.	☐ 3 MOS.
☐ 3 MOS.	☐ 6 MOS.
☐ 6 MOS.	☐ 12 MOS.
☐ MOS.	☐ MOS.
☐	☐ DO NOT DESTROY

FORM 1020B REV. (9-75)

3.1.1 Functional Requirements

The Feces Monitoring System (FMS) engineering model shall be comprised of those components and assemblies required for the collection, mass measurement, sampling and storage of feces from individual defecations.

3.1.1.1 Primary Performance Requirements

3.1.1.1.1 Collection

The FMS engineering model shall collect the total quantity of feces voided by a human subject. Specifically, the engineering model shall have the capability to accommodate the following:

a. An average input of 130 grams per defecation.
b. A maximum input of 500 grams per defecation.
c. A minimum input of 15 grams per defecation.
d. An average input of 100 grams per man-day.
e. An average of 0.75 defecations per man-day.
f. An average feces water content of 73%.
g. A feces water content range of 50 to 100%.

An individual fecal discharge exceeding the above maximum values shall not cause failure of the FMS engineering model.

3.1.1.1.2 Mass Measurement

The FMS engineering model shall automatically measure the total quantity of fecal material voided at each defecation. Each defecation shall be measured in real time with a maximum error (one standard deviation) of ± one gram or ± 2%, whichever is greater. This error requirement shall be compatible with a mass thru-put range of

125 to 1250 grams/second. A larger error shall be acceptable for mass thru-put rates outside the 125 to 1250 grams/second range.

3.1.1.1.3 Sampling

The FMS engineering model shall be capable of providing, at the option of the user, a representative sample from each defecation for in or post flight analysis. Specific requirements are as follows:

a. The minimum size of the collected sample shall be 20 grams or 20% of the total fecal mass voided, whichever is less.
b. Cross-contamination between defecations shall be minimized. The design goal shall be a maximum of 0.5 grams of fecal material carry-over between defecations.

3.1.1.1.3.1 Sample Container

Individual user identifiable sample containers shall be provided. The sample containers shall not degrade subsequent chemical or microbiological analyses or moisture content determinations. The container shall provide positive retention of the collected sample.

3.1.1.1.3.2 Preservation/Storage

The sample container design shall be compatible with low temperature storage (-20^{o} to $70^{o}C$) or lyophilization depending on the purpose of in or post flight tests. Note: Storage or lyophilization equipment are not part of the FMS engineering model.

3.1.1.1.4 Waste Disposal

The FMS engineering model shall provide integral controlled storage of excess fecal material and used wipes.

3.1.1.1.5 Equipment Requirements

The FMS engineering model shall conform to the functional block diagram of Figure 3.1-1.

3.1.1.1.5.1 Displays

The FMS engineering model shall provide a visual indication of operational status.

3.1.1.1.5.2 Power Conditioning

The FMS engineering model shall be designed to operate on nominal 28 VDC power.

3.1.1.1.5.3 Gravity Field

The FMS engineering model shall be designed for gravity independent operation. However, performance shall be demonstrated for normal earth gravity conditions only.

3.1.1.1.5.4 Configuration

The FMS engineering model shall be configured to provide both a functional and attractive appearance representative of a possible flight configuration and generally conforming to the space limitations and interfaces associated with the SHUTTLE Waste Collection System (WCS). The engineering model shall be compatible with both male and female users. The engineering model need not be optimized for minimum size, weight or power input.

3.1.1.1.5.5 Operation

The FMS engineering model shall be designed for a high degree of automatic operation. Defecation preparation time shall not exceed 30 seconds. Mass measurement and waste storage control shall be automatic.

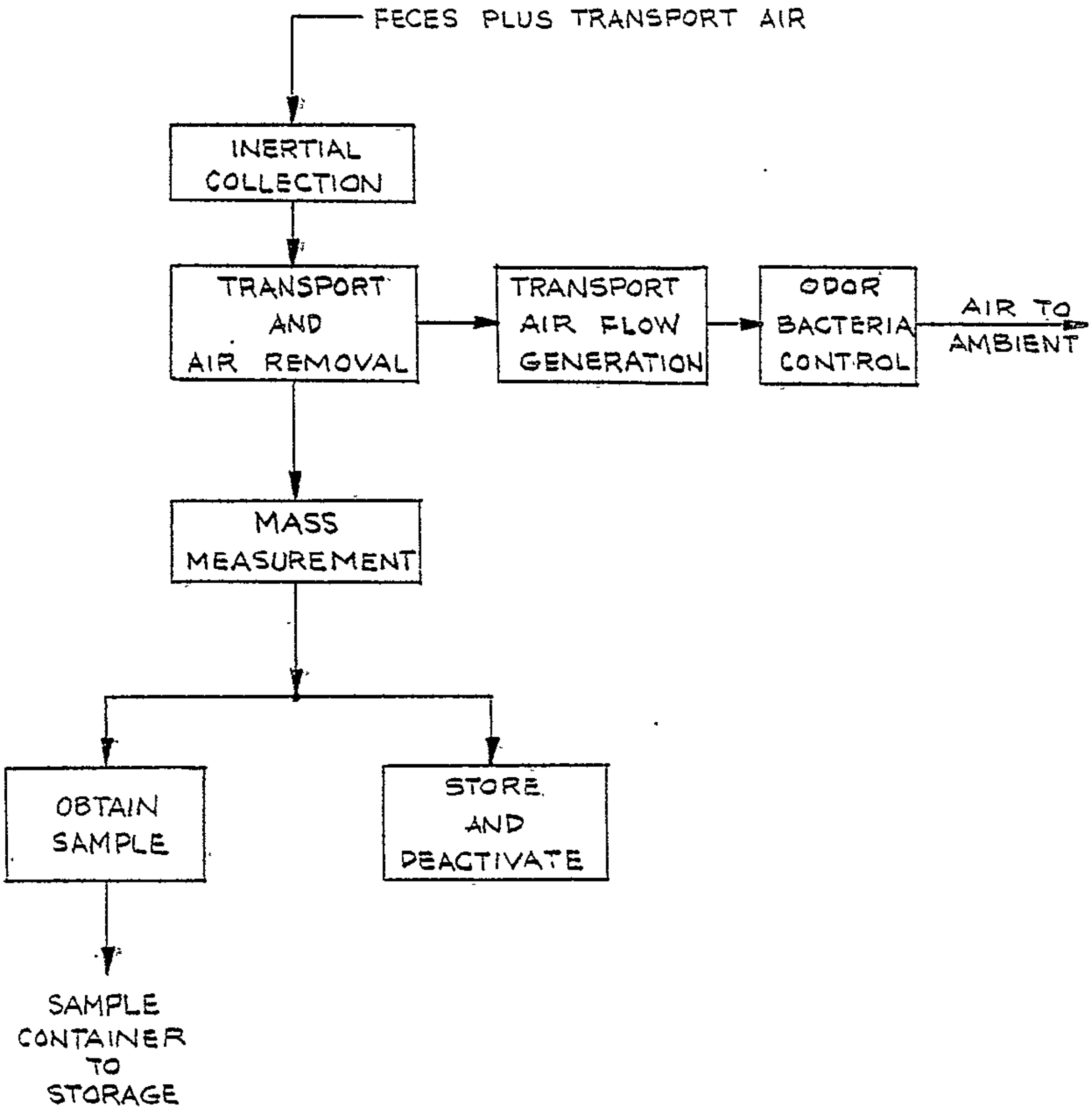

FIGURE 3.1-1 FMS ENGINEERING MODEL FUNCTIONAL BLOCK DIAGRAM

3.1.1.1.4.6 Data Output

The FMS engineering model shall correlate the corresponding feces sample container number, user ID and mass measurement data and record this information on an external recorder (not an integral part of the engineering model).

3.1.1.1.4.7 Maintenance

The FMS engineering model shall be designed to be easily maintainable including replacement of components.

3.1.1.4.8 Microorganism Control

The FMS engineering model shall be designed for automatic microorganism control of stored feces. Exposure to vacuum conditions shall be used as the control mechanism.

3.1.1.4.9 Noise

During operation, the FMS engineering model noise level shall not exceed TBD db.

3.1.1.2 Secondary Performance Requirements

The FMS engineering model shall conform to the block diagram of Figure 3.1.1.2-1 and operating sequence of Fig. 3.1.1.2-2. As appropriate, the FMS engineering model components, configuration and operation shall be identical to or approximate the SHUTTLE WCS.

3.1.1.2.1 Configuration

The FMS engineering model shall be configured to fit within the envelope shown in Figure 3.1.1.2-3.

3.1.1.2.2 Weight

The FMS engineering model shall not be weight constrained.

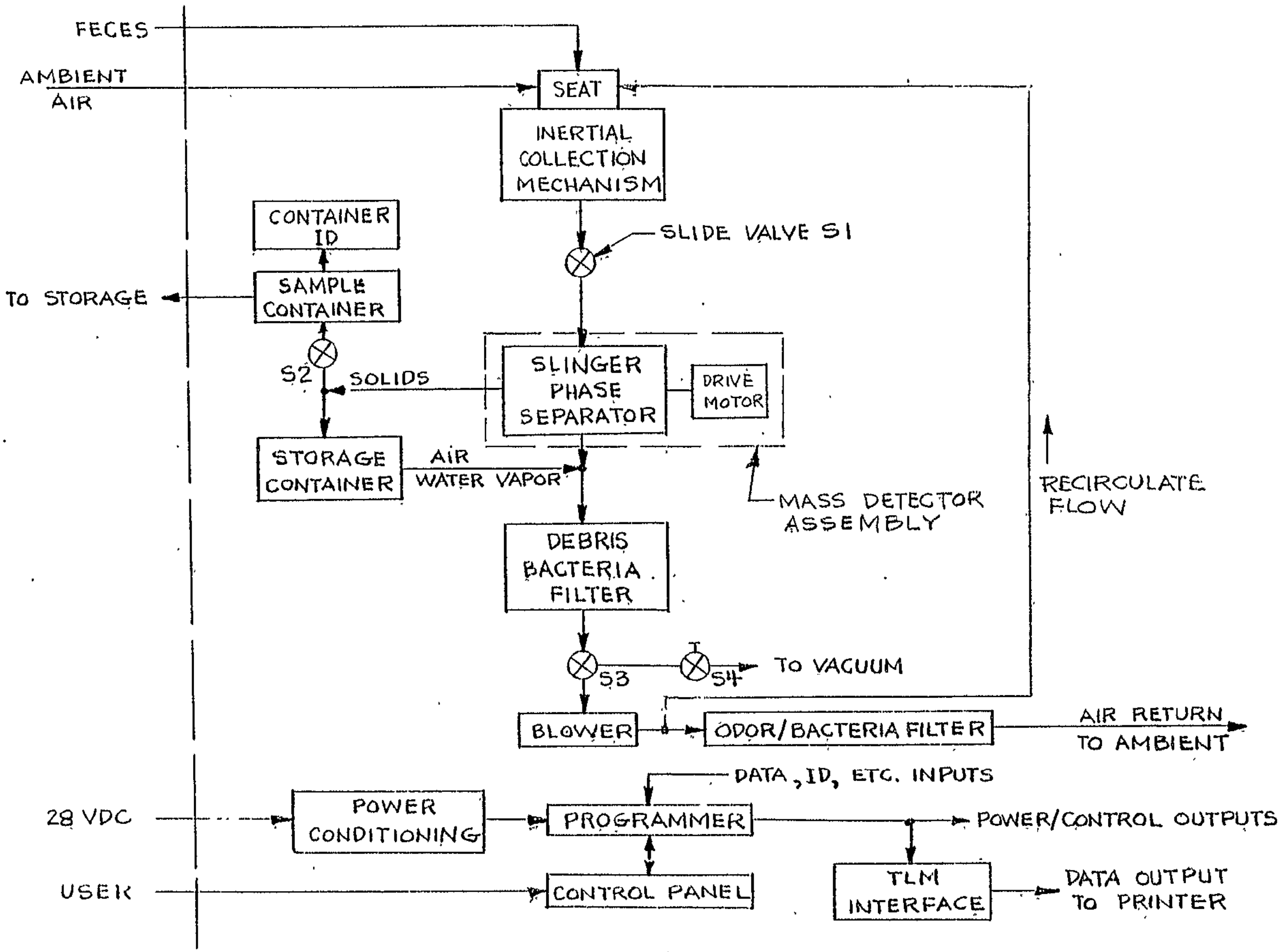

FIGURE 3.1.1.2-1 FMS ENGINEERING MODEL BLOCK DIAGRAM

POWER ON

USER OPENS slide valve

COLL RDY Light flashing

USER positions USER ID SEL switch

Operating status check

COLL RDY light solid

Mass measurement circuitry activated, obtain baseline

USER installs, extends sampling element (optional)

USER seated

USER defecates (total fecal mass measured; representative sample obtained if sampling element extended.

USER actuates SEAT ACT switch

Two cycles inertial collection sequence

USER returns sampling element to sample container

User ID, sample container ID, fecal mass data to external printer

TISSUE RDY light flashing

Tissue bypass automatic

TISSUE RDY light solid

USER WIPES

USER removes sample container

USER closes slide valve, deactivating system

Figure 3.1.1.2-2 Operating Sequence

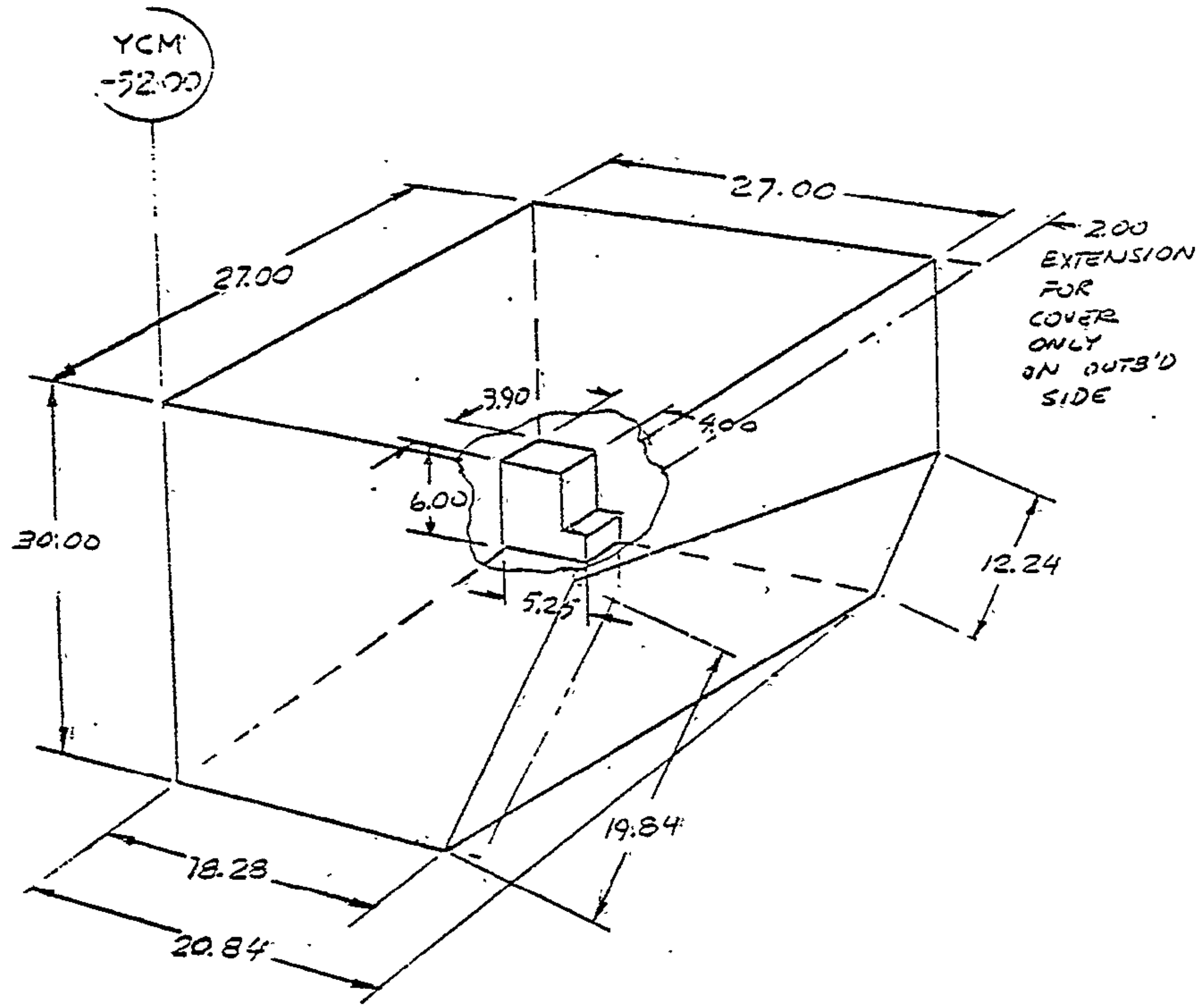

FIGURE 3.1.1.2-3 FMS Allowable Envelope
(Same as SHUTTLE WCS)

3.1.1.2.3 Component Description

3.1.1.2.3.1 Seat Assembly

The seat assembly serves to align the user in a near central position with axis of the slide valve assembly. Specific design requirements are as follows:

a. The seat opening shall be circular and a minimum 3.5 inches in diameter.
b. The seat surface shall be configured to achieve a comfortable load distribution, buttock cheek spreading and user confidence in positional alignment.
c. The seat design shall be such as to permit simultaneous use of an associated urine collection capability (not part of engr. model).
d. The seat assembly shall provide for a circumferential flow of ambient air over the user's anal area. The purpose of this airflow (generated by the blower, Section 3.1.1.2.3.8) is to control odors, assist the inertial collection mechanism (Section 3.1.1.2.3.2) in disengaging and providing transport of the feces into the system.

3.1.1.2.3.2 Inertial Collection Mechanism

The inertial collection mechanism provides the necessary inertial force to detach and convey voided feces into the system. Specific design requirements are as follows:

a. The inertial collection mechanism shall be designed for a user mass range of 50 to 100 KG (corresponding to about the 5th percentile for females and the 95th percentile for males.)
b. Activation of the inertial collection mechanism shall be controlled by the user.

c. The inertial collection mechanism shall not be capable of generating inertial forces except as a product of the activation process.

d. The magnitude of the inertial forces generated shall not endanger the user.

3.1.1.2.3.3 Slide Valve Assembly

The slide valve assembly acts as a controllable interface between the inertial collection mechanism and the remainder of the subsystem elements. Specific design requirements are as follows:

a. The slide valve assembly shall provide a controllable access to the storage container (Section 3.1.1.2.3.6).

b. The slide valve assembly shall be manually operable; operating torque shall not exceed 25 in.-lbs.

c. The slide valve assembly shall include a position detection device so that initial valve movement will activate subsystem operation sequences, if required.

d. Odors and/or microorganisms shall not be capable of migrating to ambient via the slide valve assembly.

e. The slide valve shall incorporate an interlock to inhibit opening if the storage container interior (Section 3.1.1.2.3.6) is at vacuum conditions.

f. Leakage of ambient air to vacuum thru the slide valve shall not exceed TBD cm^3/second.

3.1.1.2.3.4 Mass Detector

The mass detector assembly performs a number of closely related functions. The mass detector assembly senses the mass of the incoming fecal material. The assembly conveys the incoming fecal material into the sample container (Section 3.1.1.2.3.5)

and distributes the remainder about the inner periphery of the storage container to promote rapid drying. Specific design requirements are as follows:

a. The active element shall be a slinger, i.e., a rotating disc approximately 5.0 inches in diameter and with a minimum of 30 tines located at the periphery of and projecting at approximately 90^{o} to the surface of the disc.

b. Mass sensing shall be accomplished by integration of the incremental power input to the slinger (during transit of fecal material thru the slinger tines).

c. The slinger element shall be controlled to operate at a constant rotational speed of 2500 rpm $\pm$ 0.1%.

d. The slinger element shall be shaped and/or treated to minimize build-up of fecal solids.

e. The direction of rotation and orientation of slinger blades shall be compatible with operation of the Sampling Assembly (Section 3.1.1.2.3.4).

f. A positive means of preventing tissue build-up on the slinger element shall be provided.

3.1.1.2.3.5 Sampling Assembly

The function of the sampling assembly is to automatically collect if desired, a portion of each fecal discharge for later analysis. The assembly consists of a sample container per se, a sampling element insertion mechanism and an isolation inlet valve for interfacing with the storage container (Seciton 3.1.1.2.3.7). Specific design requirements are as follows:

a. Each sample container shall be compatible with the requirements of Section 3.1.1.1.3.

b. Each sample container shall be serially numbered (alphanumeric and format) with identification number compatible with an automatic read-out device.

c. The sample container shall be designed for sterilization prior to use.

d. The sample container shall be capable of normal handling without leakage.

e. The sample container shall interface with the storage container via an inlet valve. This valve shall only be operable if a sample container is in place.

f. The inlet valve and sampling element insertion mechanism shall be manually operated.

g. Opening the inlet valve shall be inhibited if the storage container interior is at vacuum conditions.

3.1.1.2.3.6 Storage Container

The function of the storage container is to provide aseptic storage of waste inputs. The storage container also serves as a structural support and/or to contain other system elements. Specific design requirements are as follows:

a. The storage container shall be generally circular in shape and be sized for 210 man-days of use (7 men for 30 days).

b. The storage container shall accommodate used wiping tissue as well as feces.

c. To position the liquid portion of diarrhetic discharges, an open pore foam type element shall be located within the storage container.

3.1.1.2.3.7 Debris/Bacteria Filter

The function of the debris/bacteria filter is to trap airborne microorganisms (down to virus size) prior to the return of transport air to ambient. Specific design requirements are as follows:

a. The bacteria filter medium shall be capable of removing 98% of 0.04 micron size particles and 100% of size 0.6 micron (or larger) particles.

b. A pre-filter shall be provided to minimize debris accumulation on the surface of the bacteria filter.

c. The pressure drop through the pre-filter, bacteria filter assembly shall be less than 1.0 inch of water.

d. The combination debris/bacteria filter assembly shall be sized for 210 man-days of operation.

3.1.1.2.3.8 Blower

The blower assembly provides transport air during a use cycle. Specific design requirements are as follows:

a. A nominal transport air flow of 30 cfm (STP), including a 20 cfm recirculate flow, shall be provided.

b. Acoustic insulation/tuning shall be provided as necessary to meet the noise level requirement of Section 3.1.1.1.4.9.

3.1.1.2.3.9 Odor/Bacteria Filter

The function of the odor/bacteria filter is to retain bacteria and adsorb noxious/toxic odors from the transport air prior to return to ambient. A secondary function is to act as a noise muffler for the blower. Specific design requirements are as follows:

a. The odor adsorbing media shall be activated charcoal or equal.

b. The filter shall be sized for 210 man-days of operation.

c. A check valve shall be incorporated to minimize exposure to ambient during non-operating periods.

d. The odor adsorbing media shall be upstream of the bacteria filter element.

e: The bacteria filter medium shall be capable of removing 98% of 0.04 micron size particles and 100% of 0.6 micron (or larger) particles.

3.1.1.2.3.10 Programmer Assembly

The programmer assembly shall provide the necessary functions for semi-automatic operation as well as the circuitry necessary for integration of the mass sensor signal and for proper presentation of data to the external recorder (printer). Specific design requirements shall be as follows:

a. The programmer assembly shall provide semi-automatic operation after setting of control panel switches and actuating the slide valve assembly.
b. The programmer shall integrate and scale the output of the mass detector (Section 3.1.1.1.2.3.4).
c. A microprocess shall be incorporated into the programmer to provide control and computational functions.

3.1.1.2.3.11 Power Conditioning

The function of the power conditioning capability is to provide specific DC voltages from a nominal 28 VDC input for operating the electronics or other sub-system elements.

3.1.1.2.3.12 Container ID Sensors

The container ID sensors are used to read the sample container number. The container number shall be a three digit decimal number.

3.1.1.2.3.13 Control Panel

The control panel layout shall conform to Figure 3.1.1.2-4.

3.1.1.2.3.13.1 Status Indicator

The operational status of the slinger (rotational velocity), and user ID selection shall be sensed and combined to produce a ready/not ready to use indication. A

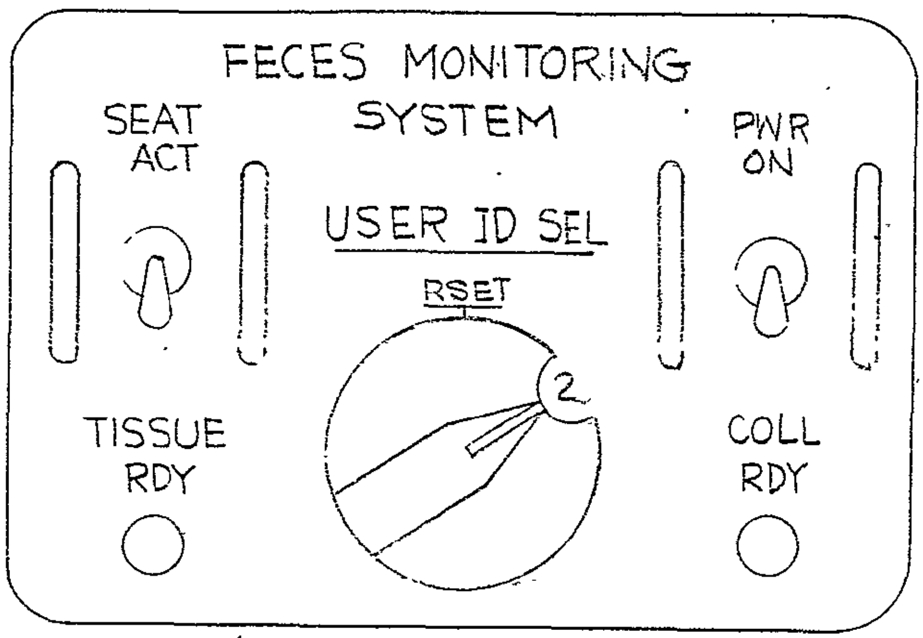

FIGURE 3.1.1.2-4 CONTROL PANEL LAYOUT (NOT TO SCALE)

ready/not ready for tissue use indication also shall be provided.

3.1.1.2.3.14 TLM Interface

The TLM interface shall condition the output data for simulated distribution to the SHUTTLE telemetry system (to the external printer for the FMS engineering model).

3.1.1.2.3.15 Structure Assembly

A structure assembly shall be provided for mounting and supporting the FMS engineering model components. Specific design requirements shall be as follows:

a. The structure assembly with other system equipments installed, shall conform to the overall envelope dimensions of 3.1.1.2.1.
b. Specific equipments shall be located to minimize potential EMI problems and length of plumbing runs consistent with normal maintenance requirements.
c. The structure assembly shall be designed to withstand normal laboratory use.

3.1.1.2.3.16 Restraints

The FMS Engineering Model shall provide mechanical restraints to assist the user in maintaining a desired physical relationship with the system. Specific requirements are as follows:

a. Lap restraints shall be fixed to the commode through a spring loaded housing with a nominal travel of 1.0 inch and a maximum pull force of 10 lbs. at each of two attachment points.
b. Hand holds shall be provided as an alternate to a lap restraint.
c. A foot restraint shall be designed to accommodate users (wearing shoes or barefoot) with a front guard height not exceeding 2.25 inches.

3.1.1.2.4 System Operation

The FMS engineering model shall conform to the following operational sequence (Reference Figures 3.1.1.2-1, 3.1.1.2-2, and 3.1.1.2.4.

1.0 Power On

1.1 Power On/Off circuit breaker switch placed in ON position at start of mission.

1.2 Power from SHUTTLE applied to system.

2.0 Collection/Mass Measurement/Sampling

2.1 User manually opens slide valve. This action applies power to system elements (blower, slinger motor, sensors, control electronics) via the slide valve interlock switch. Slide valve action also isolates the storage container from space vacuum and connects the storage container to the ambient atmosphere.

2.2 COLL RDY light activated to flashing condition until satisfactory operating status check completed by programmer (2.4 below).

2.3 User positions USER ID SEL switch via reset position.

2.4 Operating status check

2.4.1 Slinger rpm sensor check indicates rpm achieved and maintained for a minimum 5 second period and therefore slinger ready for mass monitoring. If slinger rpm outside tolerance band, COLL RDY light remains in flashing condition.

2.4.2 To minimize user ID error, the USER ID SEL switch must be returned to the RSET position before setting to user ID position. If this

sequence is not followed, the COLL RDY light remains in the flashing condition.

2.4.3 If conditions causing the COLL RDY light flashing condition cannot be corrected, instigate contingency operating procedures.

2.5 Baseline mass measurement calculation completed a nominal 5 seconds after slinger rpm sensor indicated rpm within tolerance band.

2.6 User manually installs sample container and extends sampling element (optional user action). Note: Interlock provided to prevent installation if storage container at vacuum condition.

2.7 User seated.

2.8 User defecates.

2.9 Fecal mass measured and data stored.

2.10 User actuates SEAT ACT switch. Switch actuation automatically causes two complete cycles of the inertial collection mechanism.

2.11 User returns sampling element to sample container.

2.12 A nominal 5 seconds after SEAT ACT switch actuation, user ID, sample container ID (if installed) and accumulated mass measurement data automatically sent to external recorder (printer) via the simulated telemetry interface.

2.13 A nominal 1 second after data recorded, tissue "bypass" mechanism action initiated and TISSUE RDY light activated to flashing condition. Note: If extended sampling element can interfere with the bypass mechanism action, inhibit bypass mechanism until sampling element returned to sample container.

2.14 When system ready to accept tissue, TISSUE RDY light on solid. Note: TISSUE RDY light remains in flashing condition if sampling element not returned to sampling container.

2.15 User wipes, depositing tissue in system via seat access.

2.16 User removes sample container (if installed)

2.17 User manually closes slide valve. This action removes power from the system elements via the slide valve interlock switch. Slide valve action also isolates the storage container from ambient and connects the storage container to space vacuum. Also, interlock provided to prevent removal of a sample container from storage container at vacuum condition.

3.1.2 Operability

3.1.2.1 Reliability

FMS engineering model reliability shall be achieved by reliance on maintenance procedures rather than redundancy.

3.1.2.2 Maintainability

The FMS engineering model shall be designed to provide component accessibility, replaceability, and serviceability consistent with the intended use.

3.1.2.3 Useful Life

The FMS engineering model shall be designed for a minimum useful laboratory life, with maintenance, of 12 months.

3.1.2.4 Operating Environment

The FMS engineering model shall be designed to operate under conditions normally encountered in engineering or physiological test laboratories.

3.1.2.5 Human Engineering

Human engineering factors shall be considered in the design and layout of the FMS engineering model.

3.1.2.6 Safety

3.1.2.6.1 User Safety

The FMS engineering model shall be designed to prevent hazardous conditions and inadvertent operation. Specifically,

a. Sharp edges, corners or equal shall be eliminated.

b. All electrical junction points shall be insulated or otherwise covered to prevent accidental contact.

c. All components shall be grounded to the structure with provisions on the structure for connecting to an external ground provided.

3.1.2.6.2 Equipment Safety

The FMS engineering model shall incorporate fail-safe features. Specifically, fault isolation protection shall be provided as required.

3.2 Interface Requirements

3.2.1 Urine Monitoring System

The FMS engineering model shall be capable of operating with or independent of the Urine Monitoring System.

3.2.2 Electrical

The FMS engineering shall operate on nominal 28 ± 4 VDC power from an external source.

3.2.3 Mechanical

The FMS engineering model shall be self-supporting (structurally).

3.2.4 Fluid

The FMS engineering model shall use ambient air for transport and odor control.

3.2.5 <u>Recorder Printer</u>

The FMS engineering model shall include a remotely located (to the FMS) recorder printer. The function of the recorder printer is to provide a permanent record of feces mass correlated with the user ID and sample container number. Specific requirements are as follows:

a. The printer shall have at least 4 columns.
b. The print time shall be less than 500 MS.
c. The printer shall operate on 115 VAC, 60 Hz power.
d. Tape printout format and code shall conform to Figure 3.1.2-1 and 3.1.2-2.

3.2.6 <u>User</u>

The FMS engineering model shall be designed for use by male and female subjects covering the 5th to 95th percentile range.

4.0 TEST REQUIREMENTS

4.1 <u>Quality Assurance</u>

A minimal quality assurance program shall be performed consistent with the design status of the FMS engineering model. The intent of this effort shall be to provide valid background information for subsequent program phases. Specific requirements are as follows:

	XXXX	
	XXXX	
	XXXX	
	XXXX	
	XXXX	
Line 3	0149	User No. 5, sample
Line 2	0012	Container No. 12, 149
Line 1	0005	grams feces
	XXXX	
	XXXX	
	XXXX	
Line 3	0210	User No. 7, no sample
Line 2	0000	container, 210 grams
Line 1	0007	feces
	XXXX	
	XXXX	
	XXXX	

Figure 3.1.2-1 Typical Print-Out

Line 1	XXXX	User ID (1 thru 7)
Line 2	XXXX	Sample container ID (1 to 999); 0000 if no sample container installed.
Line 3	XXXX	Feces mass, grams (1 to 999)

Figure 3.1.2-2 Tape Print-Out Code

a. Perform a preliminary FMEA, with safety emphasized.

b. Maintain configuration control records, i.e., provide a good record of what was fabricated and tested.

c. Perform laboratory tests to compare actual performance with specification requirements.

d. Fabricate in accordance with good commercial practice.

4.2 Verification

The performance of the FMS engineering model shall be determined with specific tests (laboratory and zero g environment as appropriate) as follows:

a. Verify subsystem operating conditions/cycles.

b. Verify accuracy of mass measurement.

c. Determine mass of retained sample (in sample container).

d. Determine transport air flow rate.

5.0 DATA LIST

Documentation pertaining to the FMS engineering model shall be provided as follows:

a. Performance Specification

b. Top Assembly Drawing

c. Manufacturing Drawings for Fabricated Components

d. Vendor Data Sheets for Purchased Components

e. Wiring Diagrams

f. Verification Test Report (may be combined with [g]

g. Final Program Report

APPENDIX B

FECES MONITORING SYSTEM

OPERATING, HANDLING AND MAINTENANCE MANUAL

(OM-004TB)

TABLE OF CONTENTS

SECTION 1

SYSTEM DESCRIPTION

1.1 GENERAL

The Feces Monitoring System (FMS) provides for the collection, mass measurement and sampling of feces in both a one "g" and zero "g" environment. The system is similar to the Shuttle Orbiter Waste Collector Subsystem (WCS) both physically; the FMS envelope outer appearance and mounting provisions are based upon the WCS design, and operationally; the FMS operation is based upon the WCS operating handle concept. The similarity between the systems (FMS and WCS) should minimize training of prospective users.

The collection function of the FMS employs a WCS type seat and slide valve assembly in conjunction with a servo controlled slinger. As fecal matter deposited into the commode contacts the rotating slinger, it is shredded and thrown outward against the walls of the commode. The action of the slinger causes a change in the power through the servo motor control circuit which is proportional to the mass of the fecal material. Provisions for sampling and vacuum drying the fecal material have also been incorporated into the FMS design.

The FMS does not provide for the collection of urine since it is intended for use in conjunction with a separate Urine Collection System such as the UMS developed under Contract NAS 15230.

1.2 SYSTEM FUNCTION

1.2.1 Collection and Storage

The FMS is designed for the collection and storage of feces in either a one "g" or a zero "g" environment. Patterned after the WCS, the FMS provides a WCS type collection container or "commode" suitable for the storage of a quantity of feces equivalent to that expected on a 30 day mission by a crew of six.

1.2.2 Mass Measurement

Mass measurement in the FMS is accomplished through the use of a specially designed servo motor driven slinger assembly. In operation, when feces admitted to the commode contacts the slinger, it is shredded and thrown outward toward the side of the commode. The mass measurement function is realized by monitoring the slinger motor current during the shredding action. When the fecal material contacts the slinger and/or slinger tines, the slinger servo motor, which normally operates at a constant speed of approximately 2,500 RPM is slowed slightly. The

servo motor control circuit senses this change in velocity and compensates for it by increasing the current to the motor to effect its return to the normal 2,500 RPM speed. This change in motor current and speed are proportional to the mass of the fecal material admitted to the commode. The electrical analog signal passes to an A-D converter and then to a microcomputer containing an algorithm which converts the electrical signal to a digital signal equivalent to the mass of the inputted material. This mass signal is then transmitted to a printer which prints out the mass reading along with other data to be described later.

1.2.3 Sampling

Provisions have been made in the FMS to permit collection of fecal samples. The sampling system consists of a set of individually identified sampling canisters, each containing a sampling strip. When a canister is installed in the FMS, the sampling strip can be deployed to encircle the slinger wheel. As a result, when fecal material is thrown outward by the action of the slinger, the material impinges on the collection strip instead of the commode. The collection strip surface is designed to retain the material. Upon completion of the defecation, the sampling strip can be withdrawn from around the slinger and the canister, which now contains the feces sample, can be removed from the commode and stored.

1.2.4 Inertial Seat Mechanism

As an adjunct to the collection process, an inertial seat mechanism has been incorporated into the FMS. The inertial seat is designed to overcome the aggravating situation of the stool failing to separate from the user during the act of defecation.

In operation, which is initiated by the user, the FMS seat and user are slowly raised approximately 2.5 inches above the normal position. When this position is reached, the seat is released and rapidly returns to its original position. The resulting impact resulting from the user and seat suddenly stopping the downward travel is intended to cause the separation of the stool.

1.3 SYSTEM DESIGN

1.3.1 Envelope

The design of the FMS is intended to be compatible with all aspects of the WCS/Shuttle Orbiter interface. Special attention has been paid to maintain the FMS envelope within that prescribed for the WCS.

The FMS is modular in design and consists basically of a:

1. Structure/Operating Handle Assembly.
2. Electronics/Electrical Control Assembly.
3. Power Supply Module.
4. Microcomputer Assembly.
5. Inertial Seat Drive/Sampling Module.
6. Slinger/Motor/Filter Module.
7. Commode Assembly.
8. Printer.

1.3.2 Structure/Operating Handle Assembly

The FMS structure is a tubular assembly having three legs for mounting to a simulated Orbiter interface. The legs are mounted to a ring containing five pads used for mounting the FMS Commode. In addition, the structure incorporates the FMS operating handle assembly. The operating handle consists of a series of cams and levers with suitable linkages to the FMS valves. It is designed to operate the valves in the sequence required for proper FMS operation. The assembly also contains a series of limit switches to provide electrical signals to the microcomputer indicating system start up, and to reset the computer mass measurement circuit. Switches are also provided to activate the relays to start the slinger and the blower and to stop the FMS operation.

1.3.3 Electronic/Electrical Control Assembly

This assembly consists of a control box, an electronics box and a relay rack.

The control box contains the main power switch for the FMS as well as an indicator light to show system power status. The box also houses the slinger stop switch as well as the switch to initiate operation of the inertial seat mechanism. In addition, the USER I.D. switch is housed in this assembly. The box, located at the front of the FMS, just below the operating handle, is covered by an engraved control panel.

The Electronics Box is located just below the Control Box. It houses two electronic boards. One board contains the servo motor control electronics circuit, while the other contains the circuitry required for the sample can I.D. signal as well as the signal conditioning for the sample mass signal to the microcomputer.

1.3.4 Power Supply Module

Operation of the FMS requires several different voltages. These are provided by the power supply module. Positioned behind the inertial seat mechanism, the module contains six (6) power supplies as follows:

	Supplier
1. +34.6VDC	Abbott Labs
2. -34.6VDC	Abbott Labs
3. +5VDC	Abbott Labs
4. +12VDC	Abbott Labs
5. -12VDC	Abbott Labs
6. ±15VDC	Burr Brown

The supplies are mounted on a 3/8 inch thick aluminum plate which serves as part of a heat sink to prevent thermal damage to the power supplies. The module interface with the FMS electrical circuit is via a connector located at the rear of the FMS.

1.3.5 Microcomputer Assembly

Mass measurement and signal output of the FMS is made possible by, and controlled by, the microcomputer module. The microcomputer (see Figure 1-1), containing an 8080 central processing unit and peripherals as required to satisfy the FMS requirements, provides 6 kilobytes of read only memory (ROM) and 2 kilobytes of random access memory. The FMS algorithm is contained on an EPROM to permit convenient updating of the FMS servo motor power integration and data conversion methods. Measuring 9 inches by 12 inches, the microcomputer circuit board is mounted in a box positioned beneath the FMS commode. The box is designed to protect the microcomputer circuit board from physical damage while maintaining reasonably convenient access to the assembly for removal during any extensive FMS refurbishment or for reprogramming of the system.

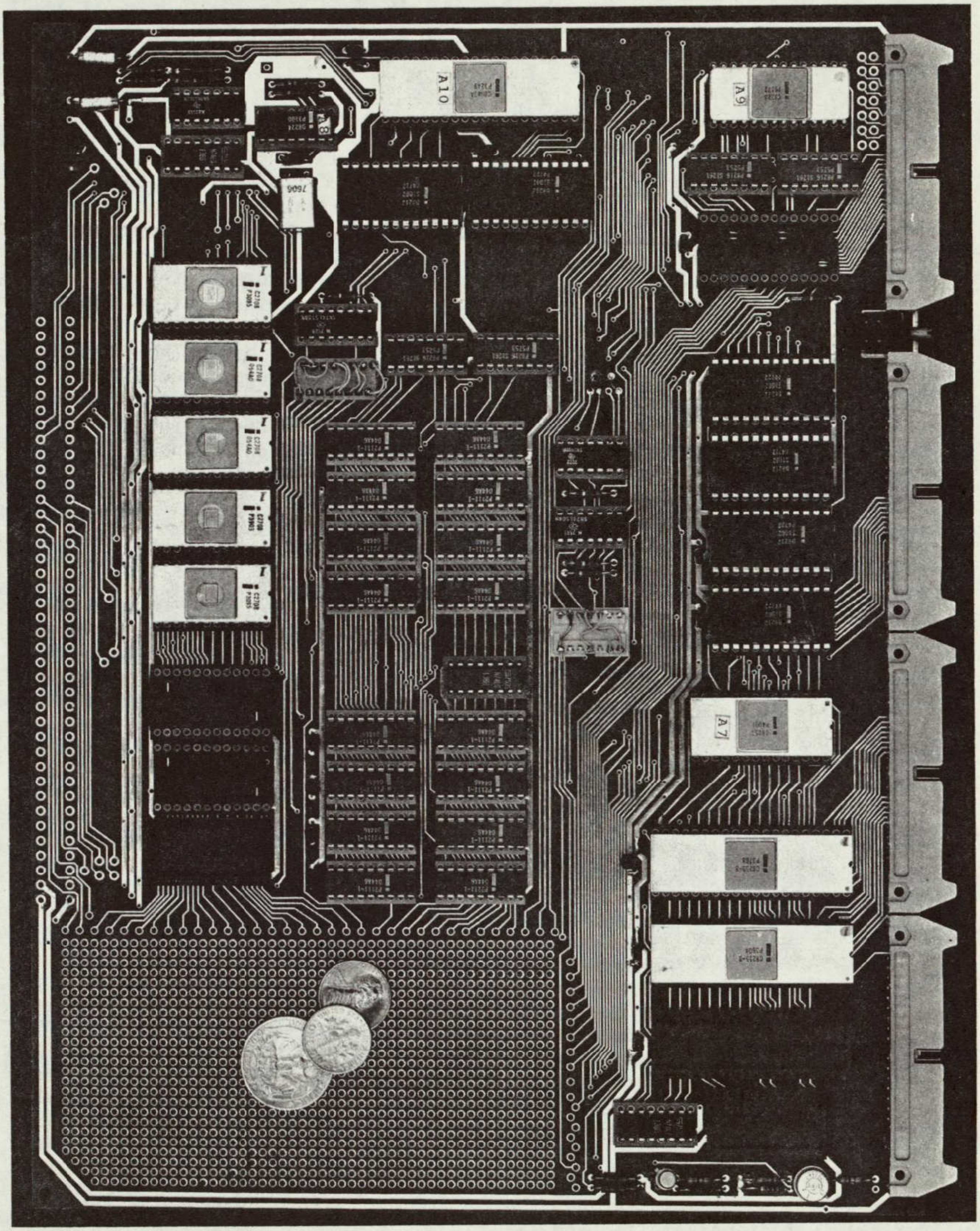

FIGURE 1-1

8080 MICROCOMPUTER

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OF POOR QUALITY

1.3.6 Inertial Seat Drive/Sampling Module

The function of this module is twofold. The inertial seat function consists of a motorized mechanism designed to impart a rapid downward motion to the FMS user followed by a sudden stop. The resulting shock is intended to effect stool separation from the user. The mechanism consists of a small high torque, low output speed gear motor which drives a large ring gear via a worm drive gear. The ring gear is attached to a cam which causes the seat to move upward on bearing followers when the motor is driven. The cam is designed to lift the seat approximately 2-1/2 inches. The force required from the gear motor is that necessary to compress a large seat return spring and to raise the user (up to 175 pounds for the engineering design). At the completion of the upward travel, the seat snaps downward sharply carrying the user with it, and stops abruptly. This action is designed to effect stool removal from the user in a zero "g" environment.

The sample valve assembly is located forward of the inertial seat mechanism. The sample valve is patterned after the seat slide valve assembly. It consists of a flat plate which, when covering the opening, provides a seal against an "O" ring and when open, provides a large port permitting installation of the comparatively large sample canister.

A latch is provided to prevent opening the slide valve before a sample canister has been installed. A second latch is provided to prevent removal of the sample canister from the valve body before the valve is fully closed.

Sample canister I.D. readout is provided by a series of opto-electric devices mounted in a modular assembly on the sample valve. The light sensors detect the pattern of a series of reflective strips on each canister. The strips are arranged to create a binary coded signal equivalent to the canister number. The canister I.D. number is fed into the microcomputer and printed out as the Sample I.D. on the system printer.

1.3.7 Slinger, Motor/Filter Module

The Slinger Motor/Filter Module is located on the inside of the commode and consists of a servo type DC motor, a folding tine slinger, a debris bacteria filter and suitable support hardware.

The module is installed in the commode via the bottom commode flange and is accessible through the top of the commode by removing the inertial seat drive/sampling module.

Design of the slinger is patterned after the WCS design, however, it is reduced in size, measuring approximately five (5) inches in diameter,

1.3.11 Printer

The printer associated with the FMS is a Texas Instruments Silent 70, Model 745, Portable Data Terminal.

C-2

SECTION II

SYSTEM OPERATION

2.1 PREPARATION FOR START UP

When the FMS has been placed in position for operation, the following connections must be made:

1. Connect the 28 VDC power cable supplied with the FMS to a suitable DC power supply, and plug the connector into the power connector at the lower left front of the FMS.
2. Connect a vacuum pump to the FMS vacuum fitting located at the lower left front of the FMS. (A tube is required for this connection.)
3. Connect the FMS Printer cable to the connector at the rear of the Silent 700 terminal.
4. Connect the Silent 700 terminal and the newly connected 28 VDC power supply to a 110 VAC power source.
5. Assure that the FMS power switch is "OFF" and then turn the 28 VDC power supply "ON."
6. Place the printer ON/OFF switch in the "ON" position.
7. The system is now ready to operate.

2.2 NORMAL OPERATION (REFERENCE FIGURE 2-1)

The operating procedure for the FMS is as follows:

1. Place the main power switch in the "ON" position. This applies power to the power supply module, the microcomputer and the "power ON" light on the control panel.
2. Place the USER I.D. knob, located on the control panel in the position which identifies the intended user.
3. Raise the FMS operating handle located on the left of the unit to the full upward position. This action causes valve V-1 to shut off the vacuum line and to permit air to flow into the commode. In addition, the slinger and blower motors start and a signal indicating system "start up" is transmitted to the microcomputer.

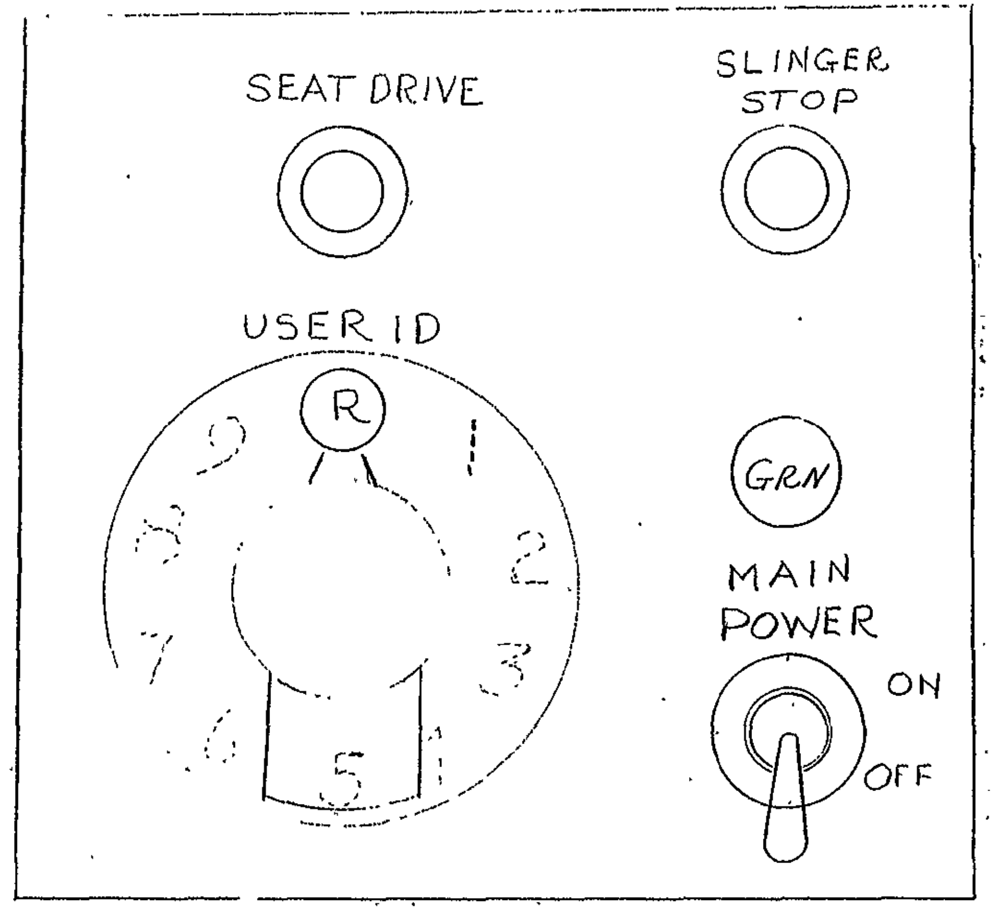


FIG 2-1 FMS CONTROL PANEL
GENERAL ARRG'T

4. After a period of approximately 10 seconds, during which time the commode is repressurizing and the slinger is reaching operating speed, the user should move the operating handle fully toward the front of the FMS. This will open the slide valve and reset the microcomputer for the subsequent use.

5. If a feces sample is to be collected, refer to Section 2.3, "Sampling."

6. User should next position himself/herself on the FMS seat, position the urinal as required, and proceed with the defecation as required. (NOTE: The urinal is not part of the FMS equipment.)

7. If it is desired to use the inertial seat, the user should depress the inertial seat drive switch button for approximately 2 seconds after which the button can be released and the motion of the seat will continue as follows; the seat will rise slowly for a distance of approximately 2-1/2 inches, at the end of this upward motion, the seat will move sharply downward for a like distance and stop suddenly. The inertial seat action can be repeated as necessary.

8. Upon completion of defecation, the user should depress the "slinger stop" switch. This will cause the mass data to be stored in the computer and will stop the slinger to facilitate waste tissue disposal.

9. If a sample canister was used, refer to instructions for removal in Section 2.3. If sample canister was not used, proceed to step 10.

10. Use wipes as required and deposit them in the seat valve opening.

11. Return the operating handle to the rearward position.

12. Return the operating handle to the downward position to complete FMS shutdown. The printer will now indicate the USER NO., SAMPLE CAN NO. (IF USED) AND MASS MEASUREMENT.

2.3 SAMPLING

2.3.1 Sampling Canister Installation

To collect a fecal sample from the FMS:

1. Perform steps 1 through 5 of the normal operating procedure.

2. Install the sample canister handle in the sampling canister assembly by aligning the "T" slot in the handle with the "T" section on the canister and sliding the two sections together.

3. Align the index mark on the canister with the index mark on the sample slide valve assembly.

4. Push the canister down until it stops (approximately 1/2 inch).

5. Open the sample slide valve by pulling the handle on the valve slide assembly toward the left. The canister is now locked in the sample valve.

6. Push the canister downward again until canister stops (approximately 1/4 inch).

7. Push the knob on the canister straight downward approximately 3 inches. This will cause the sample strip spool to move downward into the commode and engage the sample sprocket.

8. Turn the handle counter-clockwise for approximately 2-1/2 turns until it stops. (The sampling strip is now in place around the slinger.)

9. Proceed with step 6 of Section 2.2.

2.3.2 Sampling Canister Removal

To remove a fecal sample canister from the FMS:

1. Turn the canister knob clockwise 3 turns.

2. Pull the canister knob upward. The sample strip assembly should move upward in the canister. Continue upward motion until canister stops (approximately 3 inches).

3. Close the slide valve fully by moving the slide valve handle fully to the right. This will unlock the canister.

4. Remove the sample canister and store it in an appropriate receptacle. Removal of the canister will cause the sample slide valve to be locked in the closed position.

5. Proceed with step 10 of Section 2.2.

SECTION III

MAINTENANCE

3.1 GENERAL

System maintenance has been considered in the design of the FMS as evidenced by the modular design concept. Accessibility of the principal components, especially the commode components, has been made convenient.

The following discussion will indicate the procedure for removal and/or disassembly of the major components and/or modules of the FMS.

3.2 SEAT ASSEMBLY REMOVAL AND REPLACEMENT

The FMS seat has been designed to permit ready removal and re-installation. To remove the seat:

1. Remove three (3) screws connecting the seat to the spring shield. The screws are located below the front of the seat.

2. Grasp the front of the seat and pull upward and toward the front of the FMS to remove the seat.

To replace the seat:

1. Engage the seat flange under the clip at the top of the rear spring shield.

2. Push the seat front downward to engage the seat flange behind the front spring shield.

3. Replace the three (3) mounting screws.

3.3 INERTIAL SEAT/SAMPLING MODULE REMOVAL

1. Proceed as in steps 1, 2 and 3 of the Inertial Seat/Sampling Module section 3.4 of this manual.

2. Remove five (5) mounting screws (three (3) in the front and two (2) in the rear) from the module base plate.

3. Loosen the cable ties for the sample I.D. cable. DO NOT remove the strain relief holding the cable to the sample valve assembly.

4. Disconnect the Inertial Seat drive motor power cable connector.

5. Lift the module from the FMS. (NOTE: Some slack has been provided in the Sample I.D. cable. If the slack is not sufficient, remove the cable from the electronic box assembly. Do not move the sample I.D. reading module as this module requires careful alignment for proper operation.

3.4 INERTIAL SEAT/SAMPLING MODULE DISASSEMBLY

The inertial seat mechanism can be disassembled while in place on the FMS or after removal per Section 3.3. Disassembly is accomplished by two persons as follows:

1. Remove the FMS seat per section 3.2 of this manual.

2. Remove the seat cowl section of the FMS cover by removing nine (9) screws from the cowl and lifting it out of the cover.

3. Remove the slide valve assembly from the Inertial Seat Mechanism by removing four (4) screws from the slide valve assembly. The screws are located around the transport air diffuser ring. When the screws have been removed, raise the slide valve carefully and swing it to the rear of the FMS to permit removal of the Inertial Seat components. Do not bend the valve operating rod tube.

4. Remove three (3) screws from each half of the upper spring seat.

5. Using a pair of wedge shaped spring compression tools per Figure 3-1, below, place the tools on the portion of the spring adjacent to the front and rear spring shields.

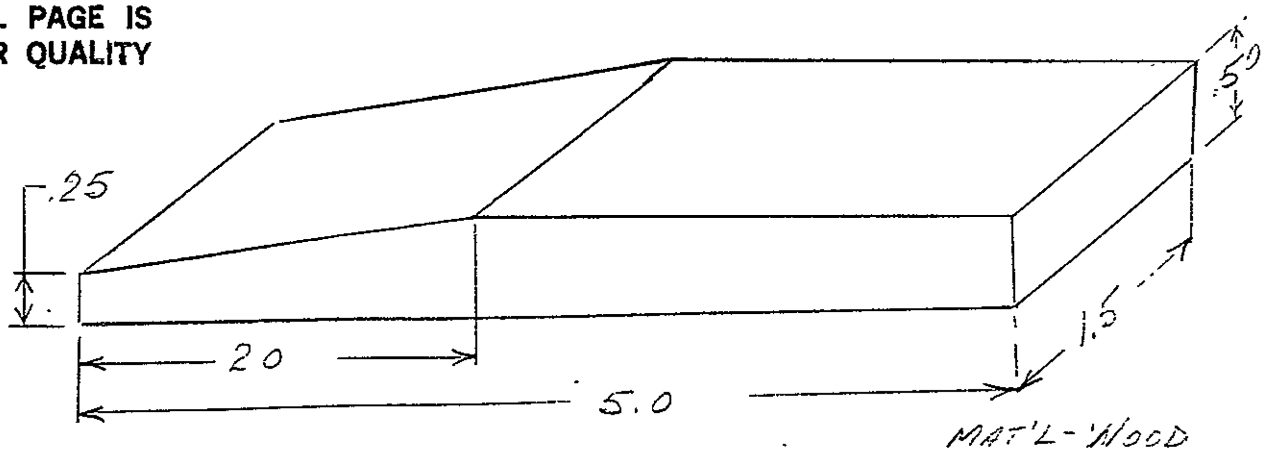


FIG. 3-1 INERTIAL SEAT SPR NG COMPRESSION TOO

6. Push down firmly on the spring compression tools to compress the spring a distance of approximately 2 inches. (NOTE: It is important that the pressure on the tools be even and balanced, and that the tools not be permitted to slip off of the spring.)

7. When the spring has been depressed, the second person should rotate the spring seat halves counter-clockwise to align the flange with the opening in the spring shields. (It may be necessary to reposition the spring compression tools to accomplish this.)

8. When the spring seats have been aligned with the spring shield opening, they can be removed by tilting the seats inward and lifting them out from behind the spring. NOTE: Maintain pressure on the spring at this point to prevent possible injury.

9. When the spring seats have been removed, the second person should assist the first by placing his palms (fingers outward on the spring) and guiding the spring upward until it is fully extended. (Approximately 12 inches.)

10. Remove the spring.

11. Lift the spring shield assembly straight up and remove it.

12. Remove the four ring gear retainers.

13. Remove the ring gear/cam assembly.

14. Remove the Drive Motor by loosening the set screw on the worm end of the motor shaft coupling and removing two screws from the motor mount base.

This completes disassembly of the Inertial Drive Mechanism.

3.5 POWER SUPPLY MODULE

Removal and Disassembly

Removal and disassembly of the Power Supply Module is accomplished as follows:

1. Remove the FMS cover per Section 3.8.

2. Disconnect the Power Supply module connector located at the rear of the FMS.

3. Remove three (3) mounting screws (two at the rear of the module, and one at the front adjacent to the largest power supply). This will free the module for removal.

3.6 MICROCOMPUTER REMOVAL

Removal of the microcomputer box from the FMS is accomplished as follows:

1. Loosen or untie all cables leading to the microcomputer.
2. Unfasten the two latches (one on each side) holding the box to the FMS frame.
3. Lift the box out of the FMS. NOTE: Care must be exercised to prevent pulling or otherwise straining the microcomputer cables.

3.7 SLINGER REMOVAL

Access to the slinger can be made through the top of the FMS commode by removing the Inertial Seat/Sampling Module or through the bottom by removing the Slinger/Motor/Filter Module. This is discussed as part of the Slinger/Motor/Filter Module disassembly.

Slinger Removal (Top Access)

To remove the slinger from the top of the commode, proceed as follows:

1. Remove the Inertial Seat/Sampling Module per section 3.3 of this manual.
2. Remove the screw from the center of the slinger wheel.
3. Grasp the slinger firmly and lift it off of the motor shaft.

3.8 COVER REMOVAL

Removal of the FMS cover is accomplished as follows:

1. Remove the knob from the operating handle by loosening the set screw in the knob.
2. Remove the foot support assembly panel from the front of the FMS by removing the mounting screws from the top and bottom of the assembly.
3. Remove the FMS cover by removing mounting screws from the periphery (rear, sides and front) of the cover, and lifting the cover from the FMS.

3.9 SLINGER MOTOR/FILTER MODULE REMOVAL

Removal of the Slinger Motor/Filter Module is accomplished as follows:

1. Cover the microcomputer box and relays with plastic film.

2. Disconnect the motor electrical connector.

3. Disconnect valve V1 from the bottom flange fitting of the commode assembly by removing four (4) socket head capscrews.

4. Remove screws from the module mounting flange. NOTE: Care should be taken prior to loosening the final screws to hold the module securely in place to prevent the module from falling from the commode.

5. When the final screw has been removed, lower the module from the commode using care to prevent damage to the filter. NOTE: It may be desirable to withdraw the module directly into a plastic bag if a possibility of contamination exists.

3.10 COMMODE REMOVAL

Removal of the commode is required for cleaning after extended use. The procedure is as follows:

1. Remove the Seat and Cover, per sections 3.2 and 3.8.

2. Remove the power supply module per section 3.5.

3. Disconnect the Sample Can I.D. cable from the electronics box.

4. Remove four (4) mounting screws from the slide valve assembly and remove the slide valve from the transport tube flange. NOTE: For odor control and sanitation reasons, it may be desirable to place a plastic bag or similar seal over the transport tube opening.

5. Disconnect the slinger motor power connector.

6. Disconnect the vacuum line and the line to the blower from the FMS valve V1.

7. Remove mounting bolts from the five (5) commode mounting pads.

8. Lift the commode from the support structure and place in a suitable facility for cleaning.

9. Remove the Inertial Seat/Sampling Valve Module from the commode as described in Section 3.3.

10. Upon completion of step 8, turn the commode over.

11. Remove the Slinger/Motor Module as described in Section 3.9.

FMS DRAWING TREE

SK 15159-4

OUTBOARD PROFILE

SK15159-12 General Arrgt

- SK15159-20 Storage Container
- SK15159-50 Commode Details
- SK15159-43 Plate-Mounting
- SK15159-31 Tube-Transport
- SK15159-62 Slinger Housing
  - SK15159-61 Filter Support
- SK15159-69 Filter Debris Bacteria
  - SK15159-63 Filter Housing Components
- SK15159-64 Mounting Slinger Motor
- SK15159-34 Slinger Assembly
- SK15159-37
- SK15159-36
- SK15159-38
- SK15159-40 Gear Drive
- SK15159-41 Retainer, Gear Assembly
- SK15159-32 Seat, Spring Lower
- SK15159-30 Seat, Spring Upper
- SK15159-33 Seat, Gear
- SK15159-35 Frame, Slide Valve
- SK15159-66 Lock, Slide Valve
- SK15159-60 Housing Sample Can I.D.
- SK15159-39 Sample Slide Valve
- SK15159-48 Lock Sample Canister
- SK15159-49 Retainer, Sample Valve Lock
- SK15159-71 Reflective Sensor Assembly
- SK56198-880 Cam
- SK56198-871 Spring, Axial Motion

SK15159-42 Sample Can Handle
SK15159-47 Sample Can Tube Assembly
SK15159-45 Sample Can Cover Assembly
SK15159-67 Sample Can Tube
SK15159-46 Sample Can Spool Assembly

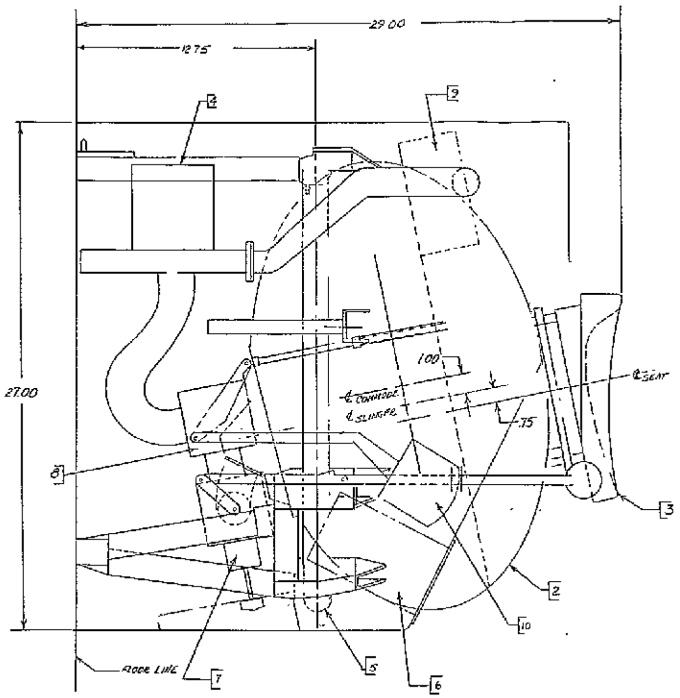
- SK15159-44 Sample Can Spool Top
- SK15159-70 Sample Can Spool Base
- SK15159-68 Sample Can Shaft
- SK15159-65 Sample Can Sample Strip

SK15159-91 FMS Control Circuit Diagram

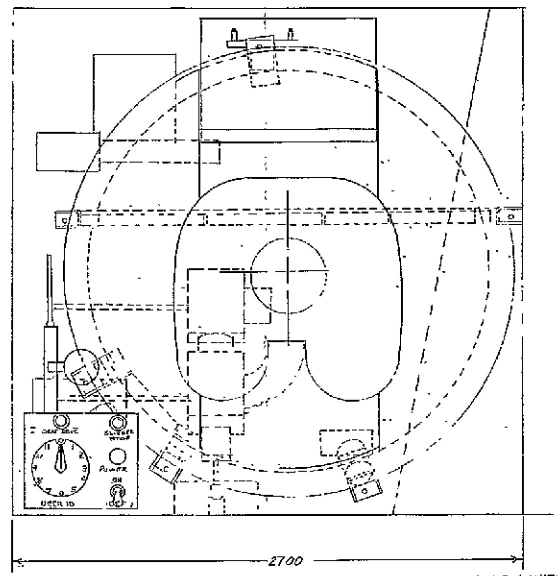
SK15159-90 Microprocessor Board Schematic

SK15159-22 Analog Signal Processing Electronics

2 FOLDOUT FRAME



SIDE VIEW
(FOOT SUPPORT NOT SHOWN)



PLAN VIEW WITH COVER AND FOOT SUPPORT REMOVED

FWD

G2	G1	IDENTIFYING NUMBER	ITEM NO	DESCRIPTION	MATERIAL	REFERENCE	REMARKS
			10	OPERATING HANDLE ASSY			
			9	CANNISTER-CHARCOAL			
		47A232869	8	VALVE ASSY			FLODYNE
		47A232861	7	VALVE ASSY			FLODYNE
			6	CONTROL BOX			
		47J232825G1	5	SUPPORT STRUCTURE			
		47A226363	4	BLOWER			IMC
			3	SEAT			
		SK15159-5	2	FMS CONTAINER			
		SK15159-4	1	FMS GEN'L ARRGT			

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES — TOLERANCES ON: 2 PLACE DECIMALS ± 3 PLACE DECIMALS ± ANGLES ± FRACTIONS ± ALL SURF ✓ MATERIAL—

GENERAL ELECTRIC

FMS
OUTBOARD PROFILE

SIZE E — SK 15159-4

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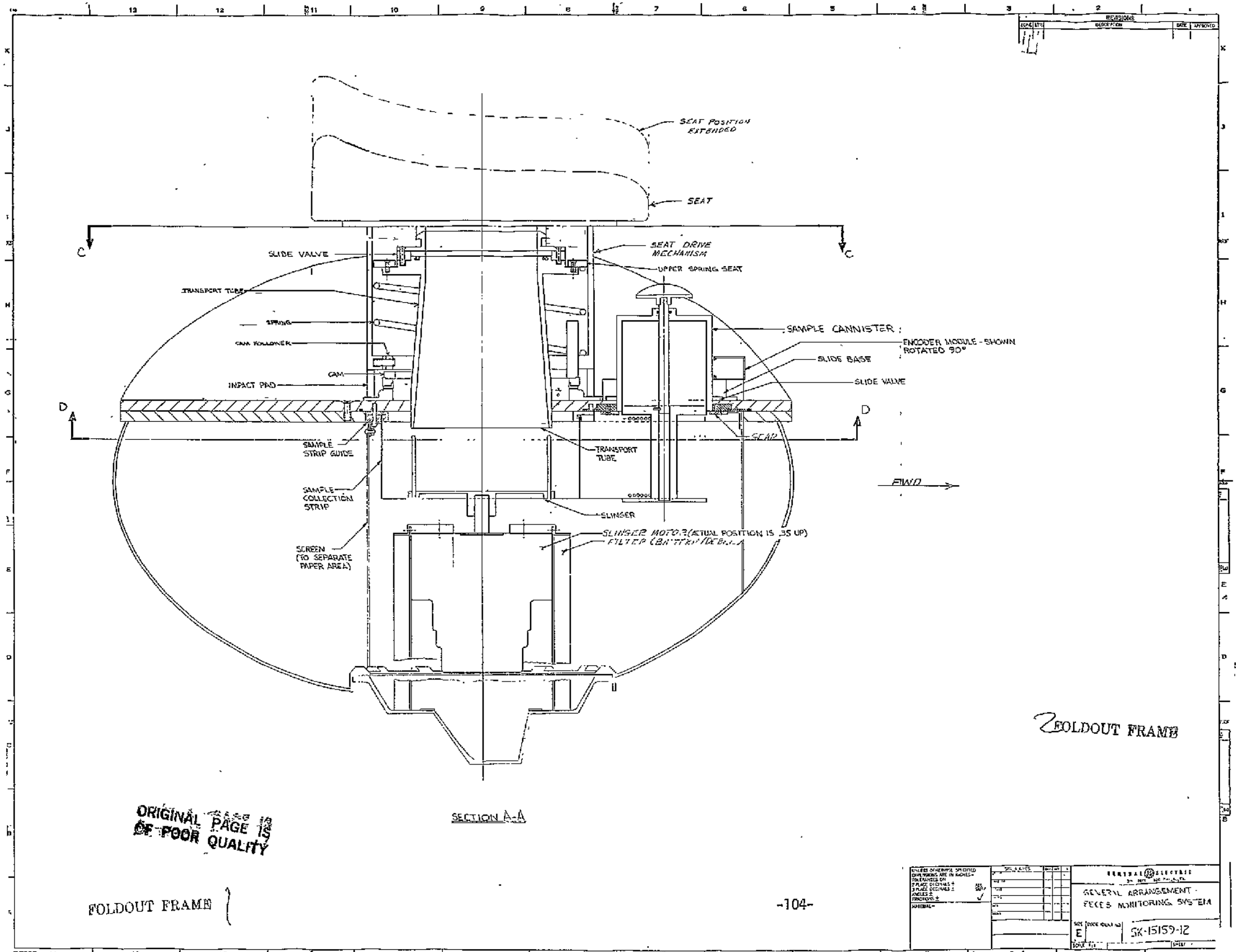

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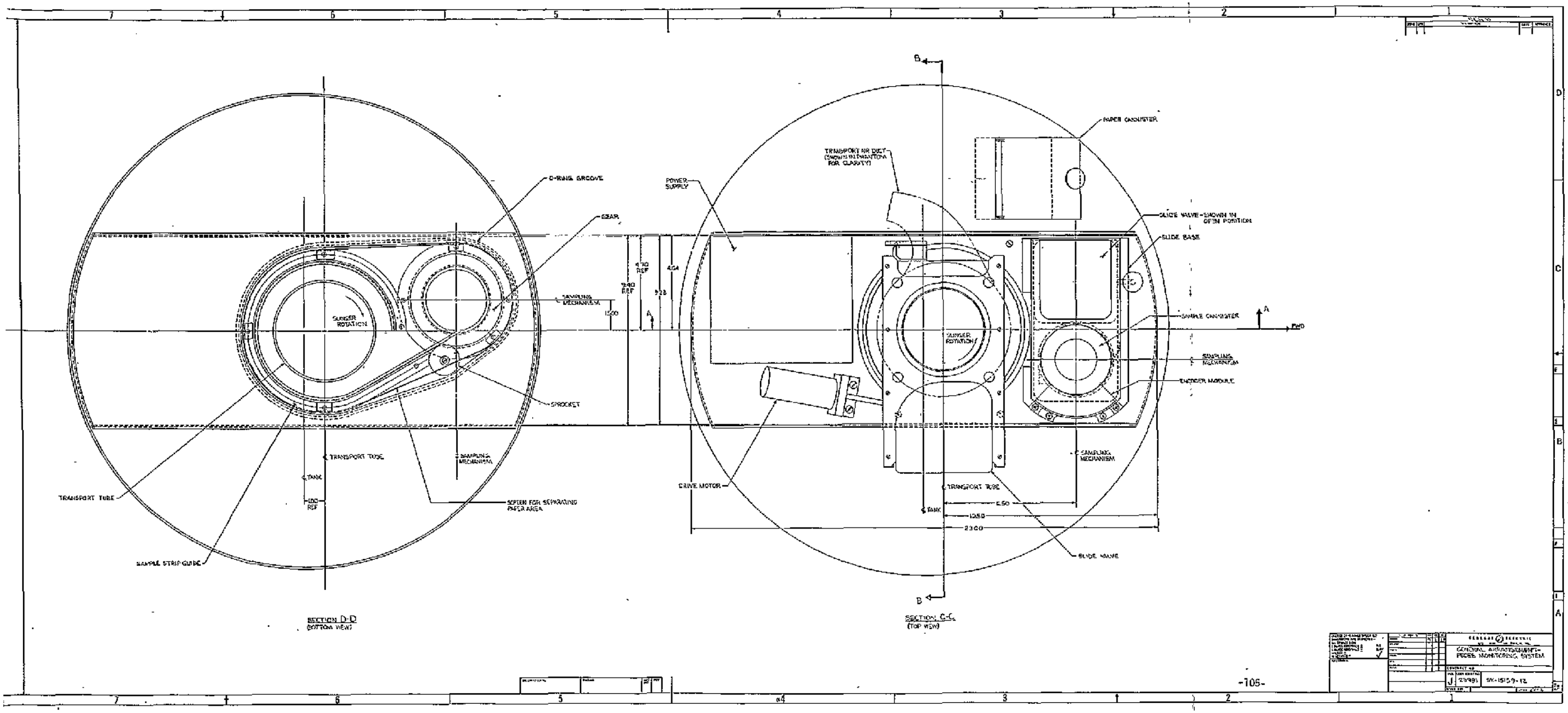

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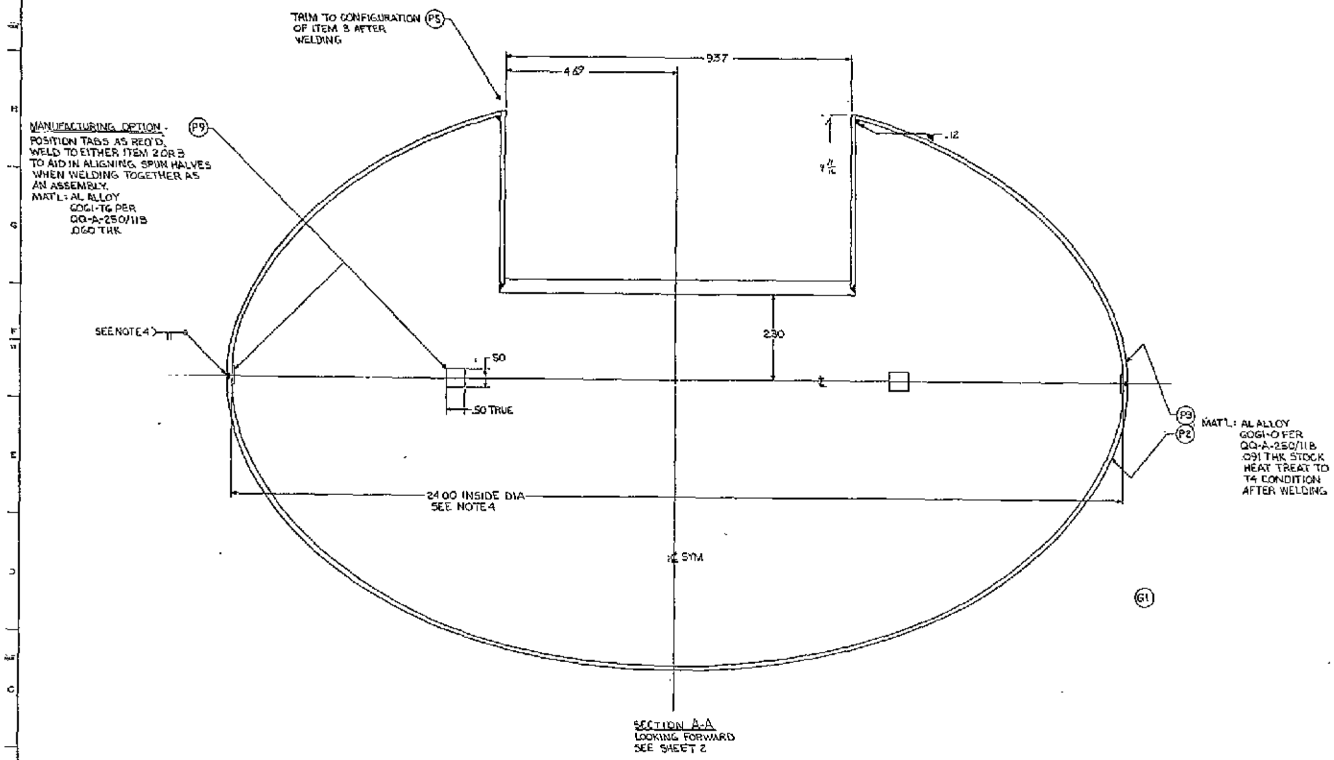

NOTES:

1. DRAWING TERMS AND TOLERANCES PER 530009.
2. MARK 23991-47E P_ OR G_ AS APPLICABLE PER 118A1526CL21E.
3. ITEMS 2 AND 3 TO BE SPUN SO THAT THEY FORM AN ELLIPSODIAL SHAPE HAVING AN INSIDE MAJOR DIA OF 24.00 AND AN INSIDE HEIGHT OF 15.30 BEFORE MACHINING CUTOUTS FOR FLANGES ITEMS 4 AND 5. RADIAL SURFACE FLATS DUE TO SPINNING MUST NOT EXCEED .100 IN WIDTH.
4. WELD PER 146A9614 CL III. ARGON FLUSH INTERNALLY WHILE WELDING. DEPRESSIONS IN ITEMS 2 AND 3 CAUSED BY WELDING MUST NOT EXCEED .062.
5. FINISH - ANODIZE PER MIL-A-8625C TY II CL2.

FOLDOUT FRAME 1

FOLDOUT FRAME 2

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

GENERAL ELECTRIC

STORAGE CONTAINER - FECES MONITORING SYSTEM

SIZE	CODE IDENT NO	
E	23991	SK-15159-20

SCALE 1/1

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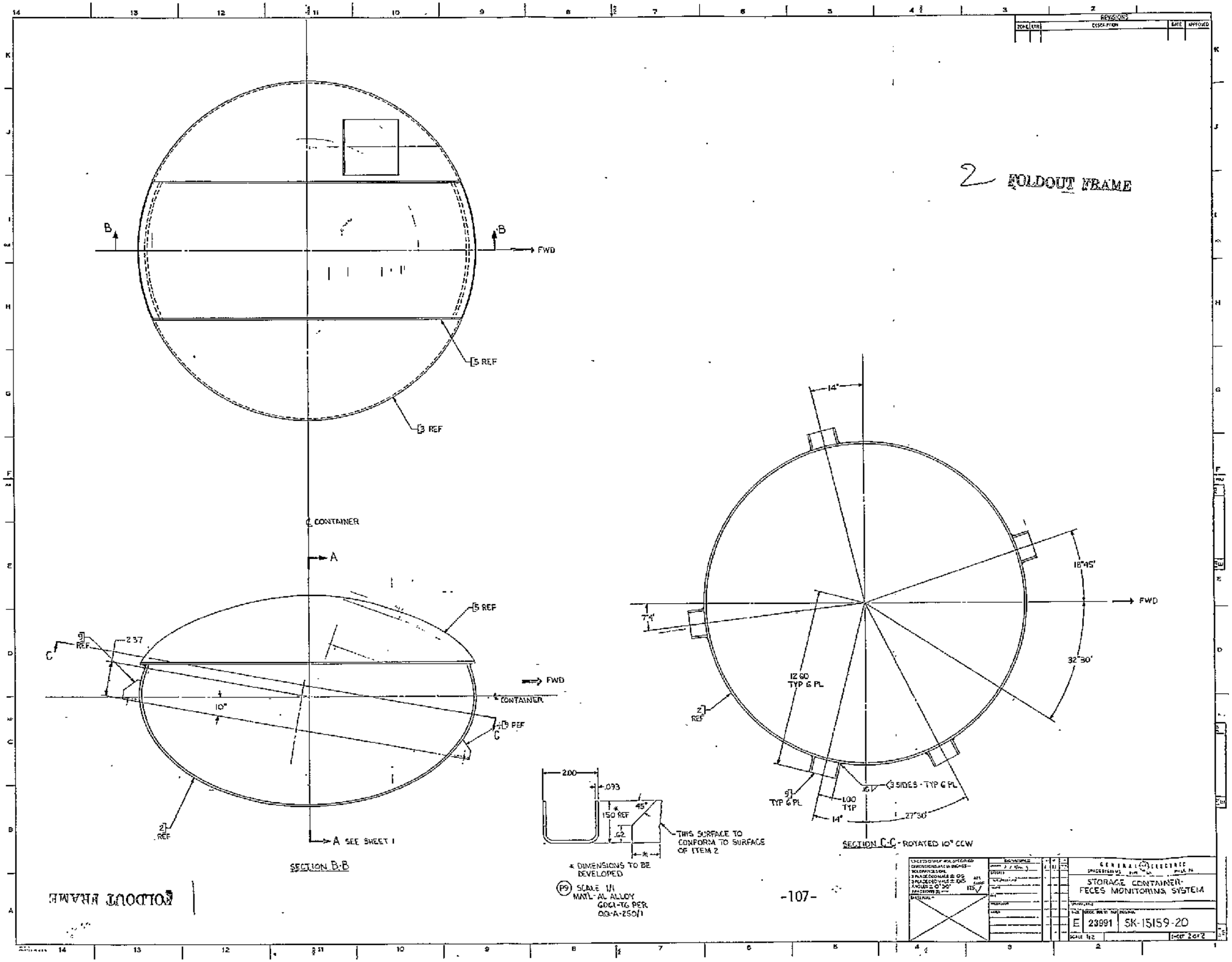

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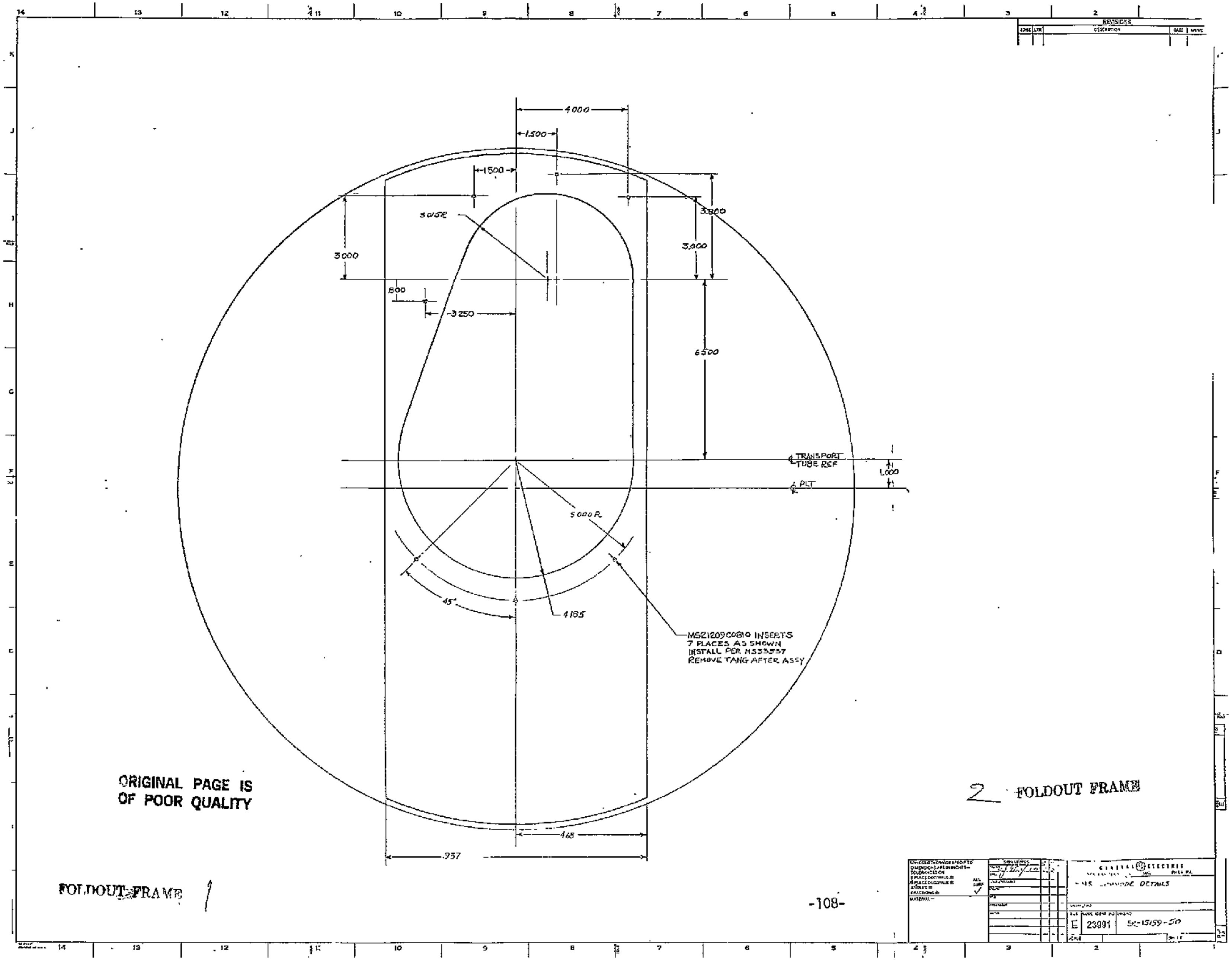

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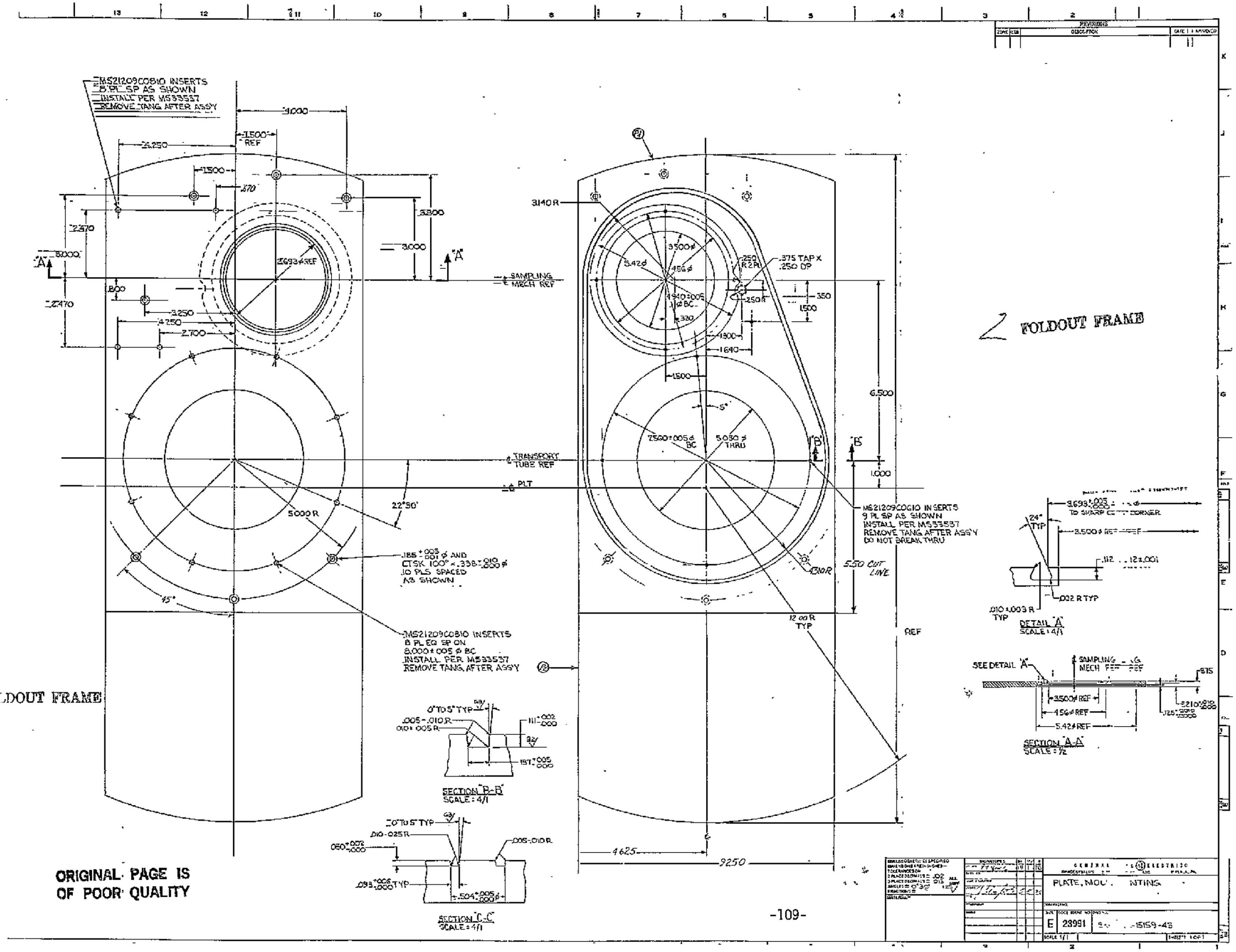

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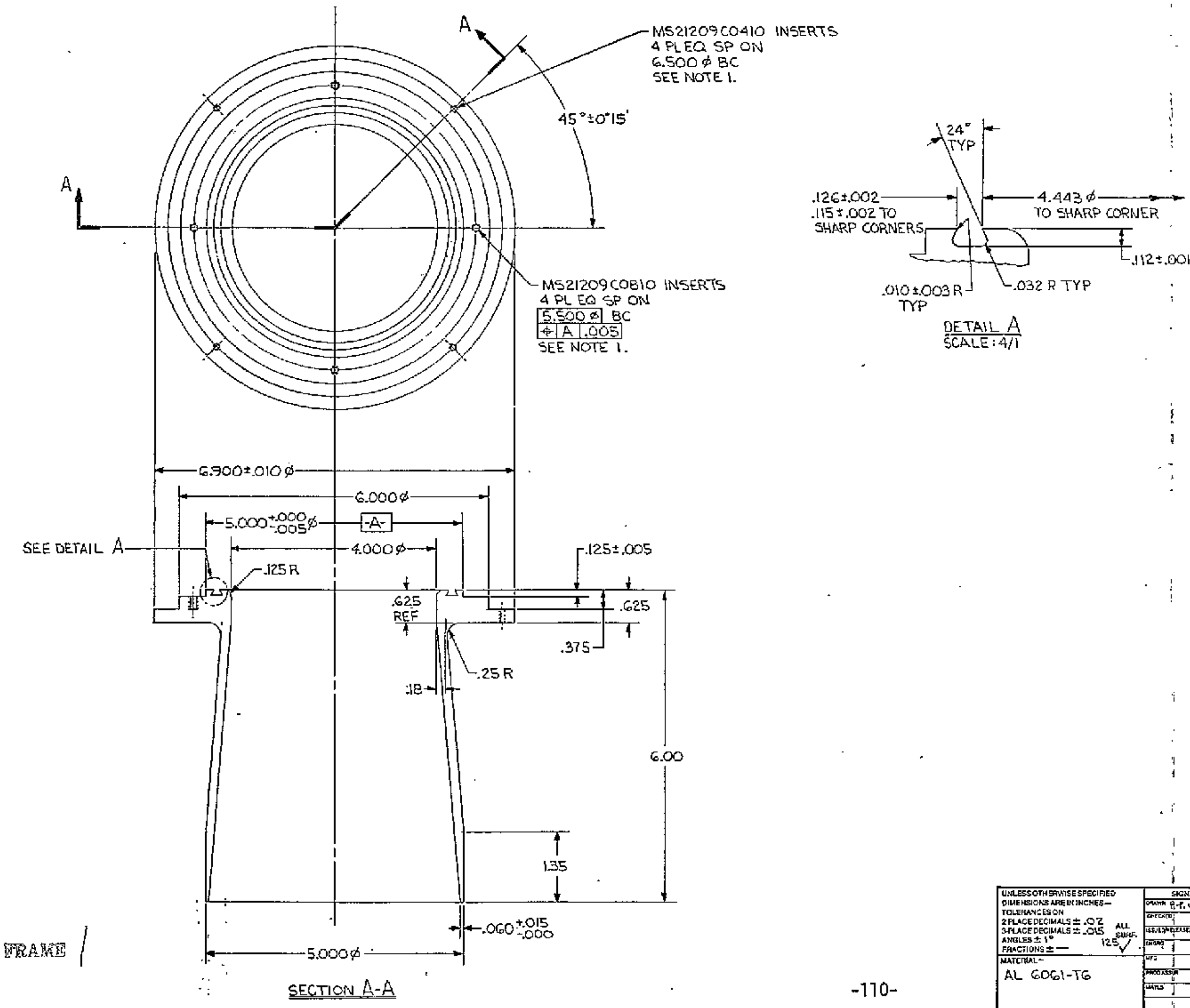

NOTES:

1. INSTALL INSERTS PER MS33537 CL2B. REMOVE TANG AFTER ASS'Y.

2 FOLDOUT FRAME

FOLDOUT FRAME 1

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES— TOLERANCES ON 2 PLACE DECIMALS ± .02 3 PLACE DECIMALS ± .015 ANGLES ± 1° FRACTIONS ± — ALL SURF. 125	GENERAL ELECTRIC SPACE SYSTEMS PHILA., PA.
MATERIAL— AL 6061-T6	TUBE, TRANSPORT
DRAWN 7 12 77	SIZE D CODE IDENT NO 23991 DWG NO SK-15159-31
	SCALE 1/1 SHEET 1 OF 1

SK-15159-31

C SK-15159-37

REVISIONS				
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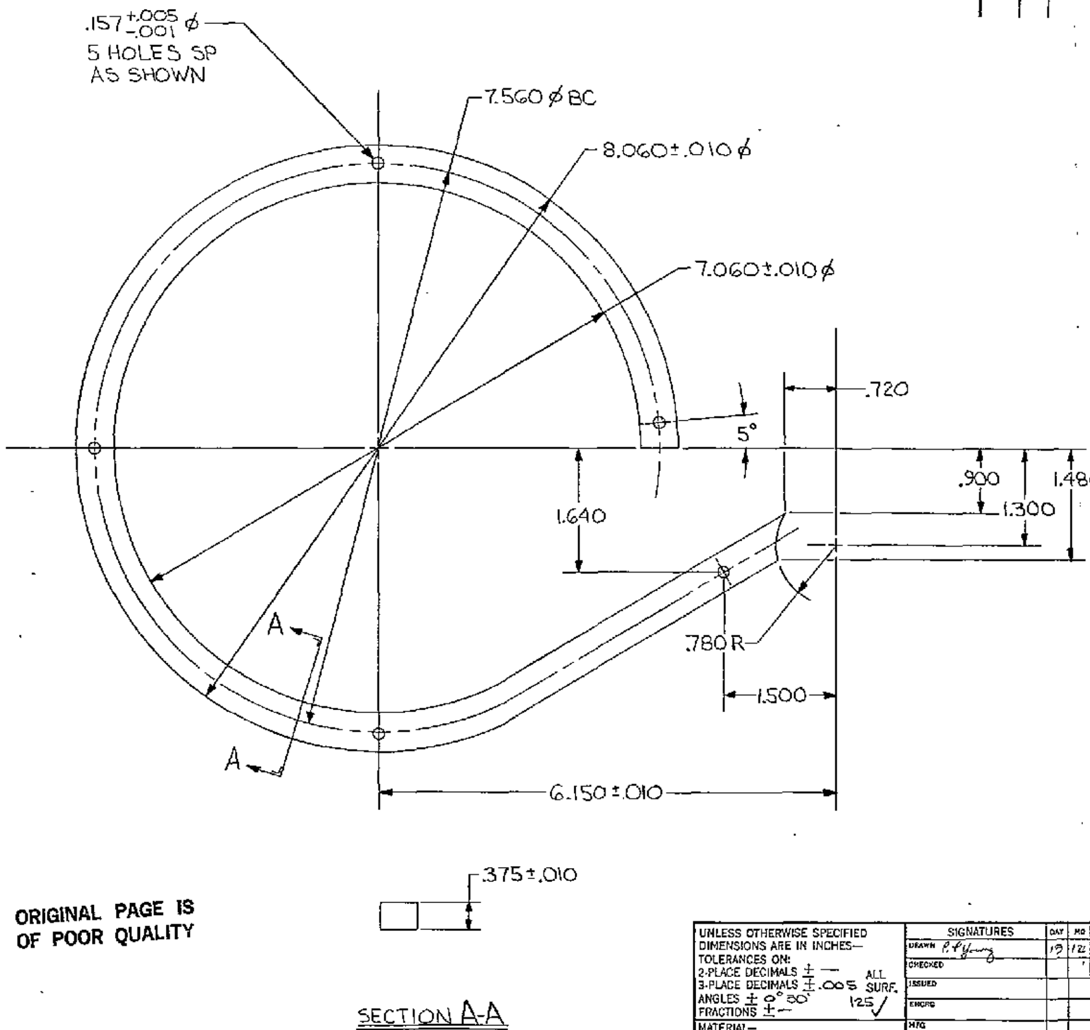

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UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES—
TOLERANCES ON:
2-PLACE DECIMALS ± —
3-PLACE DECIMALS ± .005
ANGLES ± 0° 30'
FRACTIONS ± —
ALL SURF. 125

MATERIAL—
AL ALLOY
6061-T6

SIGNATURES	DAY	MO	YR
DRAWN P. F. Young	19	12	77
CHECKED			
ISSUED			
ENGRG			
MFG			
MATLS			

GENERAL ELECTRIC
55 DEPT LOC PHILA, PA

GUIDE, SAMPLE STRIP

SIZE	CODE IDENT NO.	
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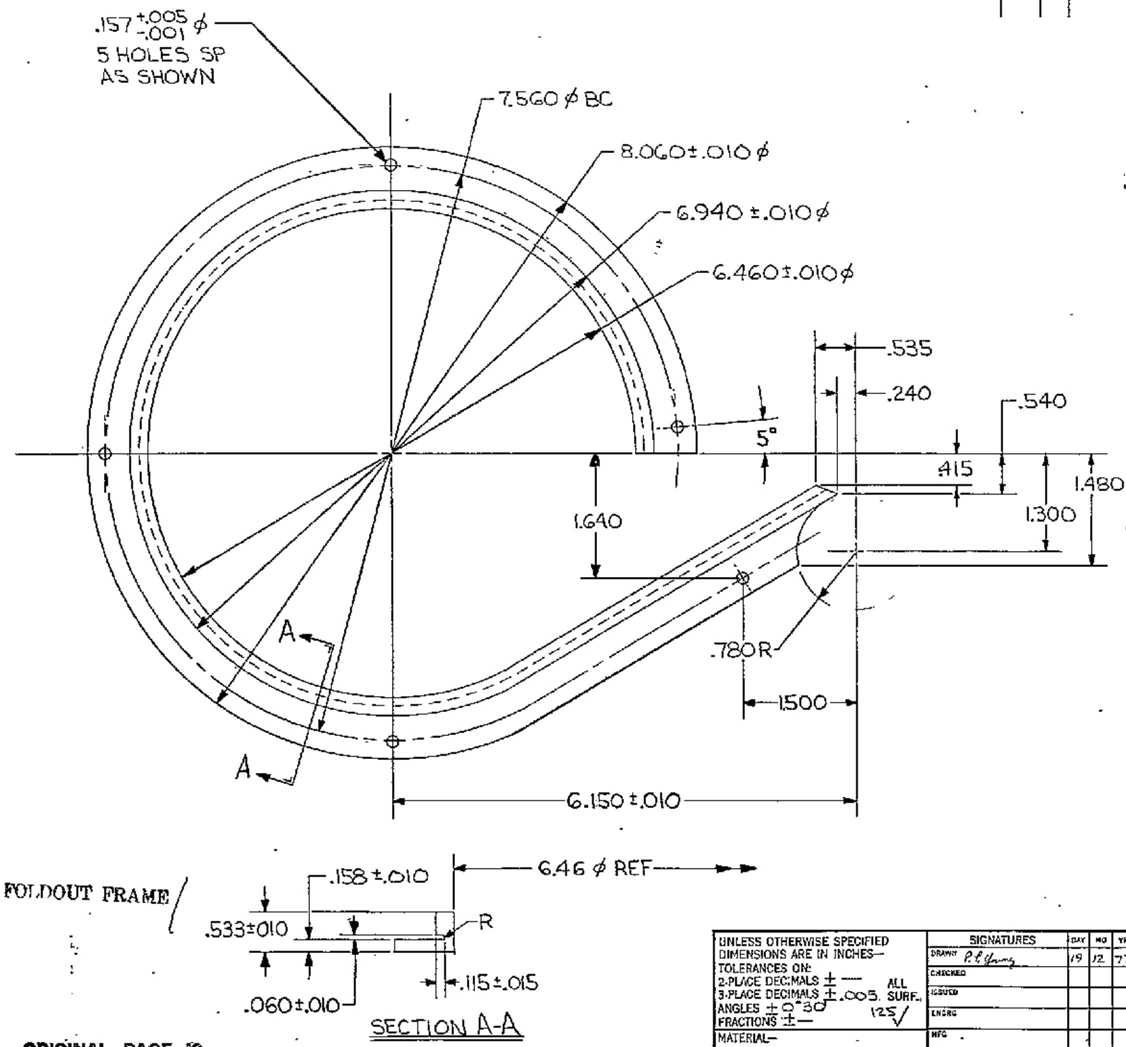
SCALE 1/1		SHEET 1 OF 1



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MATERIAL— AL ALLOY 6061-T6	

GENERAL ELECTRIC
SS DEPT LOC PHILA, PA

TRACK, SAMPLE STRIP

SIZE	CODE IDENT NO.	
C	23991	SK-15159-36
SCALE 1/1		SHEET 1 OF 1

SIZE C SK-15159-36

SIZE C SK-15159-38 REV

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED

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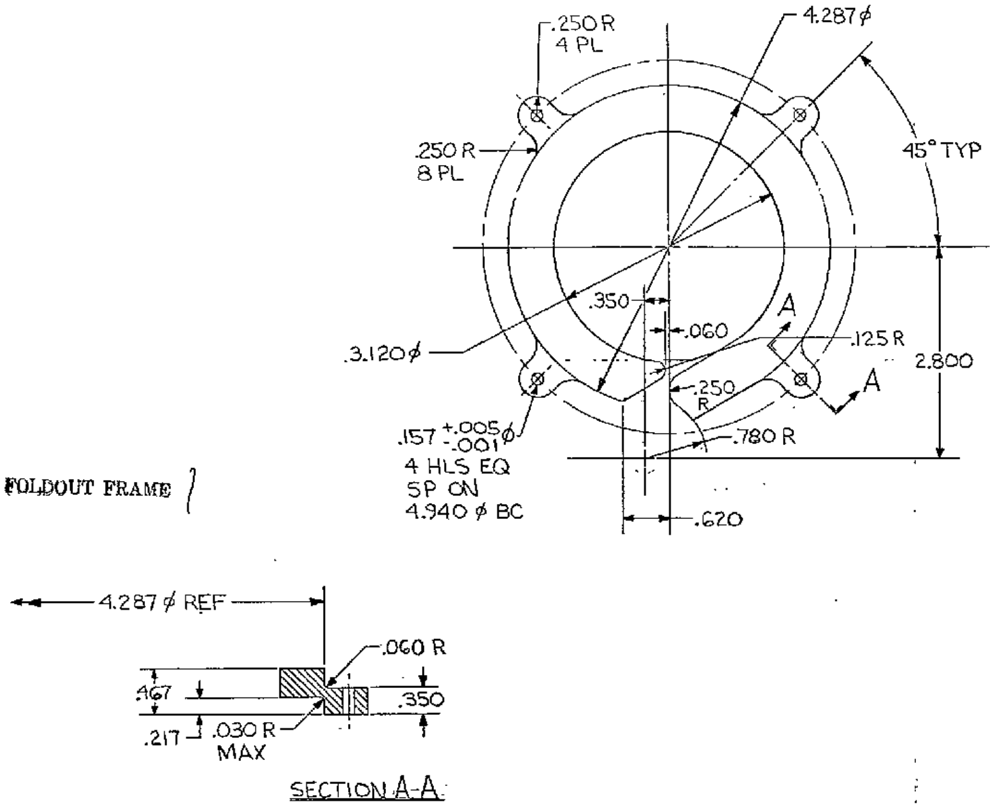

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UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES— TOLERANCES ON: 2-PLACE DECIMALS ± — 3-PLACE DECIMALS ±.010 ANGLES ±0°30' FRACTIONS ± — ALL SURF. 125√	SIGNATURES	DAY	MO	YR
	DRAWN P. F. Young	19	12	77
	CHECKED			
	ISSUED			
	ENGRG			
MATERIAL— AL ALLOY 6061-T6	MFG			
	MATLS			

GENERAL ELECTRIC
SS DEPT LOC. PHILA, PA

GUIDE, STARTER - SAMPLE STRIP

SIZE	CODE IDENT NO.	
C	23991	SK-15159-38
SCALE 1/1		SHEET 1 OF 1

SIZE		SHEET	REV
A	SK-15159-41	1 OF 1	

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED

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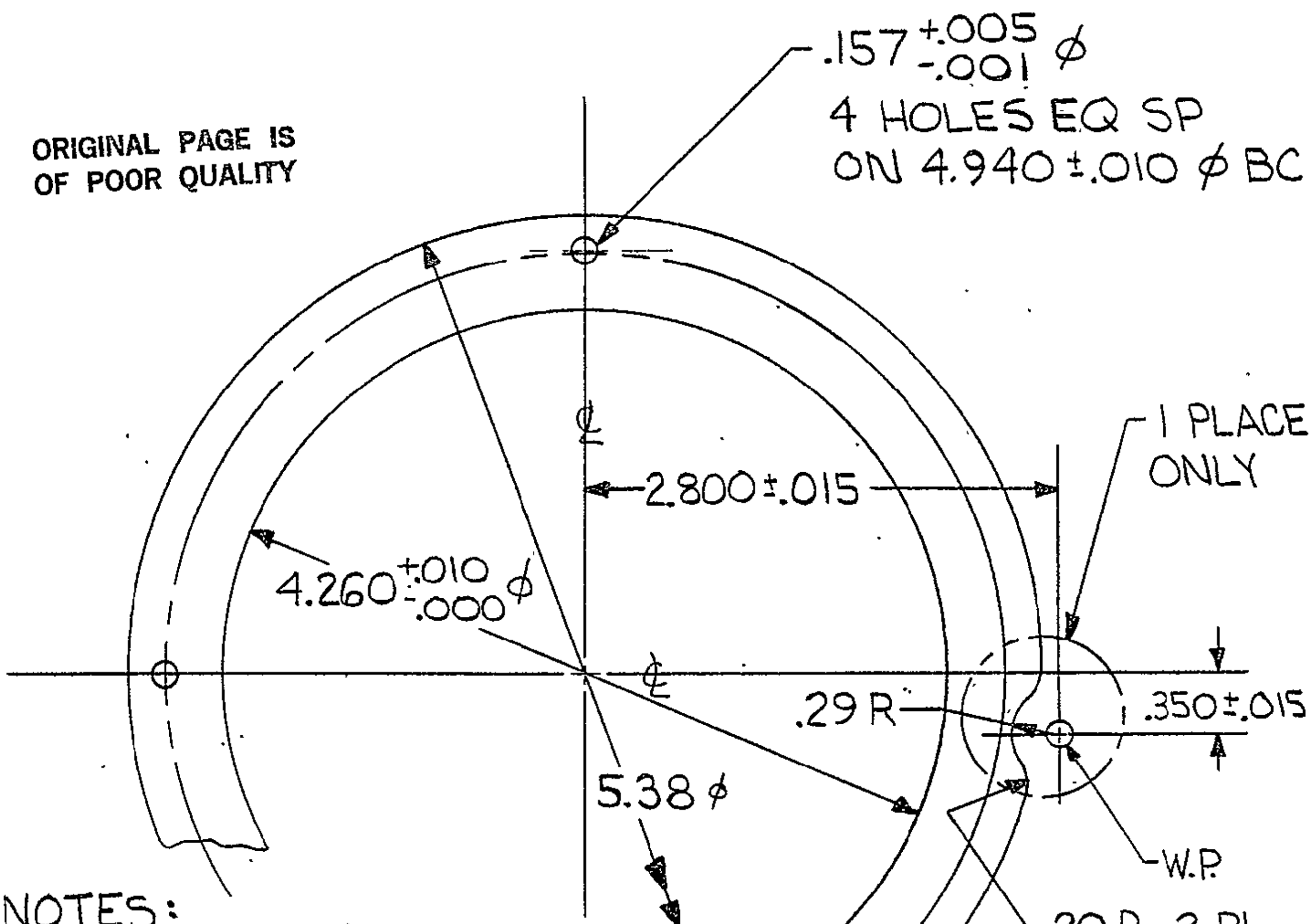


NOTES:

1. MAT'L THK TO BE .125±.010
2. FINISH: TUFRAM COAT TYPE C22 (.002 TOTAL THK OF COATING) PER MIL-A-8625C TYPE III WITH TEFLON IMPREGNATION

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON:	SIGNATURES		DAY	MO	YR
FRACTIONS ± — DECIMALS ±.02 ANGLES ± —	DRAWN	P. F. Young	20	12	77
ALL SURFACES 125 √	CHECKED				
MATL. AL ALLOY 6061-T6 SEE NOTES	ISSUED				
	ENGRG				
	MFG				
	MATLS				

GENERAL ELECTRIC
SS DEPT LOC PHILA, PA

RETAINER, GEAR ASS'Y

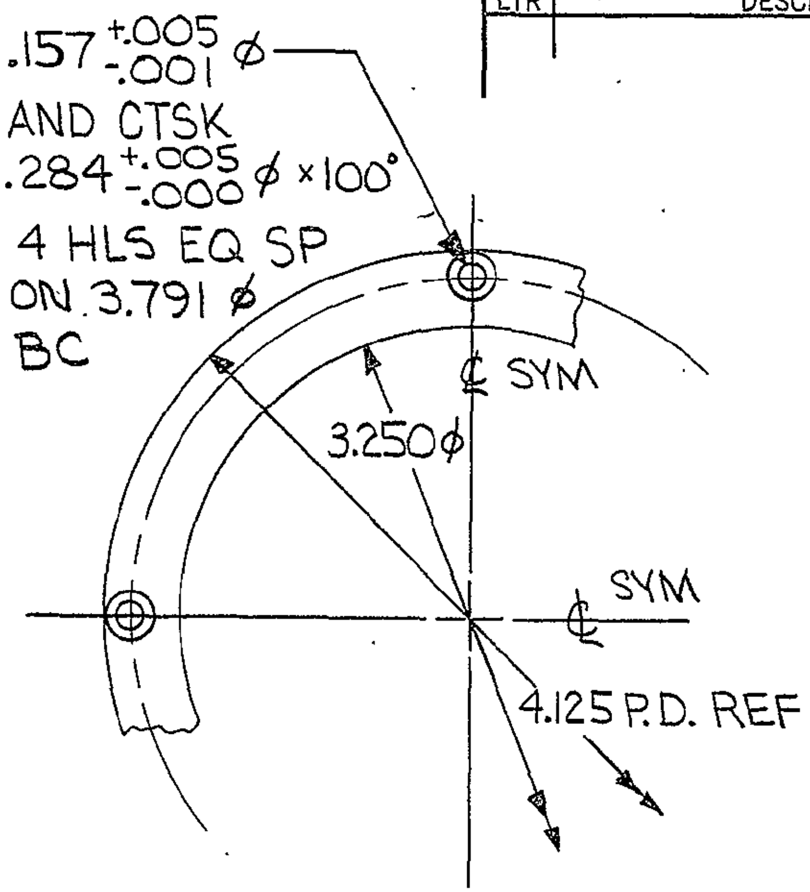
SIZE	CODE IDENT NO.	
A	23991	SK-15159-41
SCALE 1/1		SHEET 1 OF 1

DIST TO

F 301-F (9-64) REV PRINTED IN U.S.A.

SIZE		SHEET	REV
A	SK-15159-40	1 OF 1	

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



MAKE FROM PIC P/N J1-198

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON:
FRACTIONS ± — DECIMALS ±.010 ANGLES ± —
ALL SURFACES 125 ✓
MATL-

SIGNATURES		DAY	MO	YR
DRAWN	P. P. Young	19	12	77
CHECKED				
ISSUED				
ENGRG				
MFG				
MATLS				

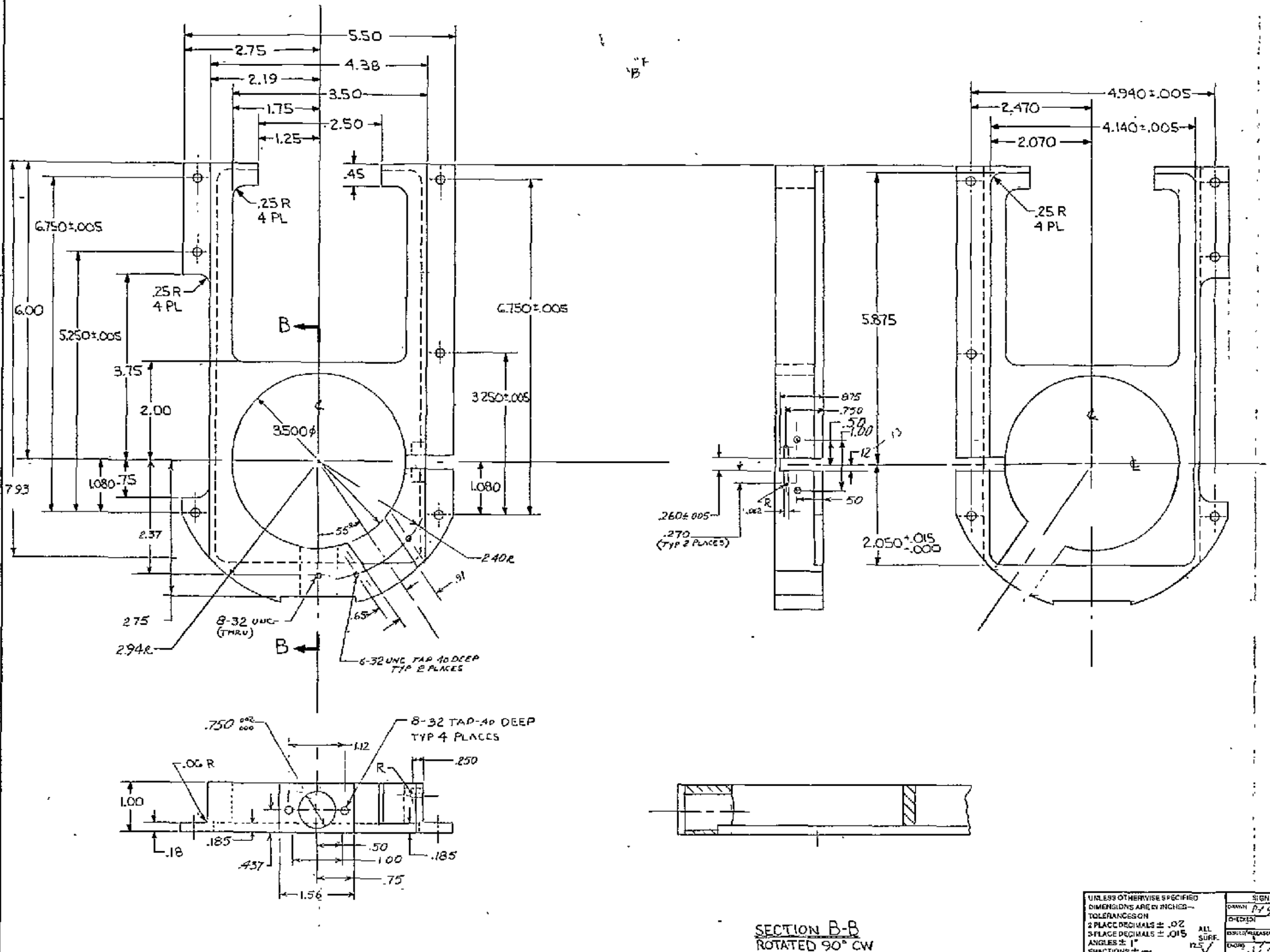
GENERAL ELECTRIC
SS DEPT LOC PHILA, PA

GEAR, DRIVE

SIZE	CODE IDENT NO.	
A	23991	SK-15159-40
SCALE 1/1		SHEET 1 OF 1

DIST TO

FN-901-F (9-64) REV PRINTED IN U.S.A.



NOTES:

1. FINISH: TUFRAM COATING TYPE C22 (.002 TOTAL THICKNESS OF COATING) PER MIL-A-8625C TYPE III WITH TEFLON IMPREGNATION.

2 FOLDOUT FRAME

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES — TOLERANCES ON 2 PLACE DECIMALS ± .02 3 PLACE DECIMALS ± .015 ANGLES ± 1° FRACTIONS ± — ALL SURF. 125

MATERIAL — AL ALLOY 6061-T4/T6

GENERAL ELECTRIC SPACE SYSTEMS PHILA., PA.

FRAME, SLIDE VALVE - SAMPLE OPENING

SIZE D CODE IDENT NO 23991 DWG NO SK-15159-35

SCALE 1/1 SHEET 1 OF 1

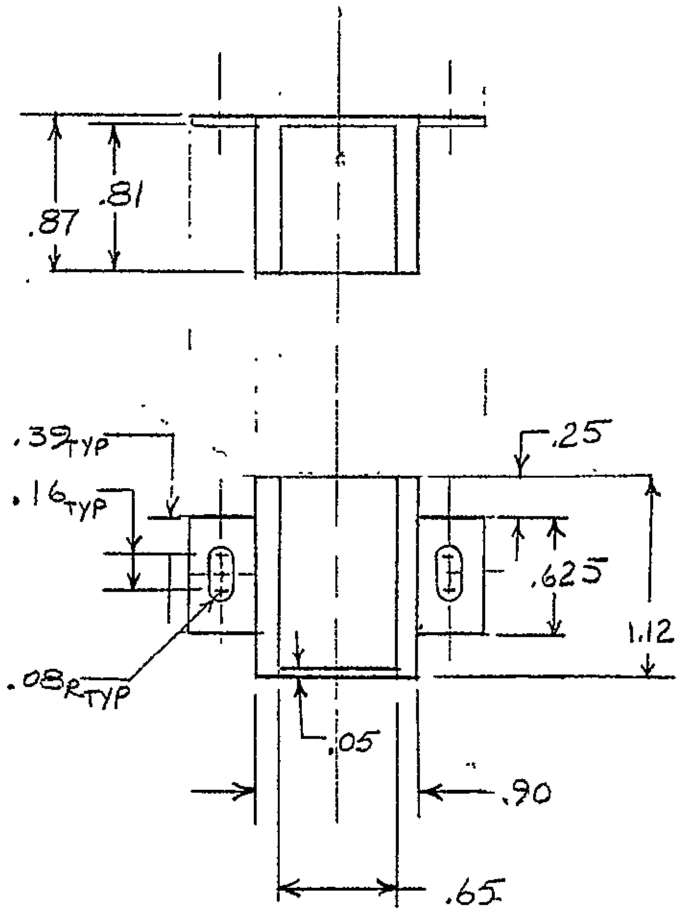
SK-15159-35

FOLDOUT FRAME 1

SIZE A		SHEET	REV

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED



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UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON:
FRACTIONS ± DECIMALS ± ANGLES ±
ALL SURFACES ✓
MATL.

SIGNATURES		DAY	MO	YR
DRAWN	GKY	11	10	78
CHECKED	C			
ISSUED				
ENGRG				
MFG				
MATLS				

GENERAL ELECTRIC
DEPT LOC

HOUSING - SAMPLE CAN ID MODULE

SIZE	CODE IDENT NO.	
A		SK15159-60
SCALE		SHEET

DIST TO

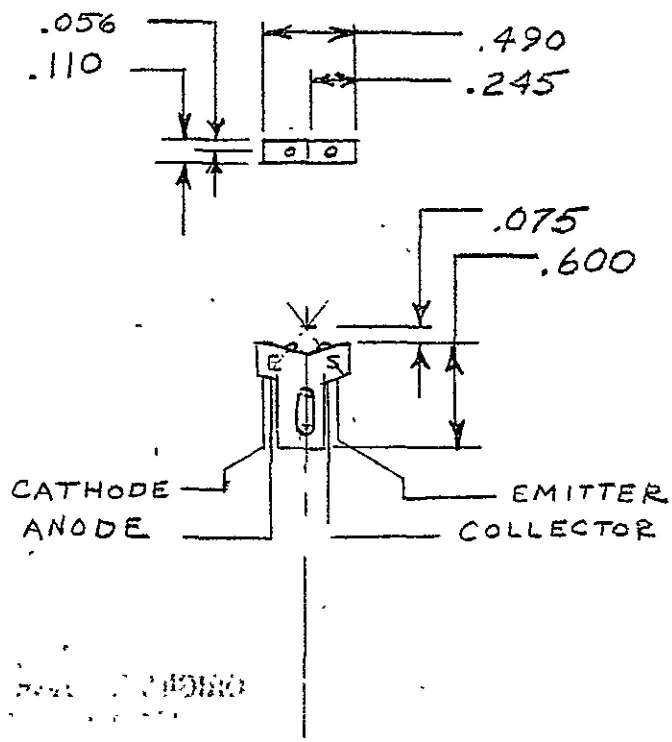
FN 901P (5-66) PRINTED IN U.S.A.

SIZE	SHEET	REV
A		

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

SOURCE:
SPECTRONICS INC

TYPE SPX 2820



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON:	SIGNATURES	DAY	MO	YR
FRACTIONS ± DECIMALS ± ANGLES ±	DRAWN EJd	1	10	78
	CHECKED			
	ISSUED			
ALL SURFACES ✓	ENGRG			
MATL-	MFG			
	MATLS			

GENERAL ELECTRIC
DEPT LOC

REFLECTIVE SENSOR ASSY

SIZE	CODE IDENT NO.	
A		SK 15159 - 71
SCALE		SHEET

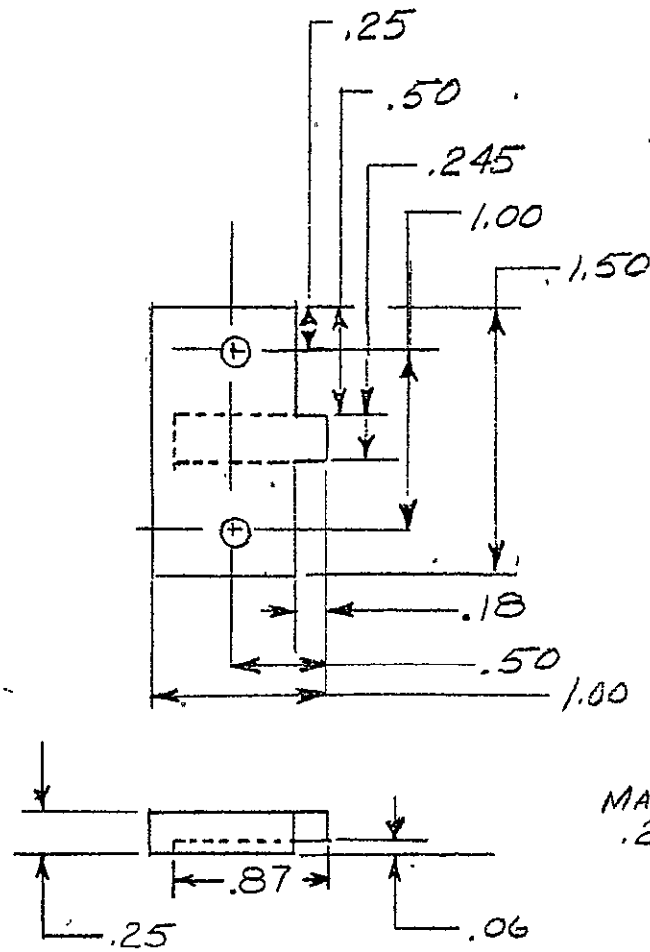
DIST TO

FN-301P (12-68)

SIZE A		SHEET	REV

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED



MATL ALUM. ALLOY
.25 THK STK

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON:	SIGNATURES	DAY	MO	YR
FRACTIONS ± DECIMALS ± ANGLES ±	DRAWN EJA	11	7	78
	CHECKED			
	ISSUED			
ALL SURFACES ✓	ENGRG			
	MFG			
MATL-	MATLS			

GENERAL ELECTRIC
DEPT LOC

RETAINER - SAMPLE VALVE LOCK

SIZE	CODE IDENT NO.	
A		SK 15159-49
SCALE		SHEET

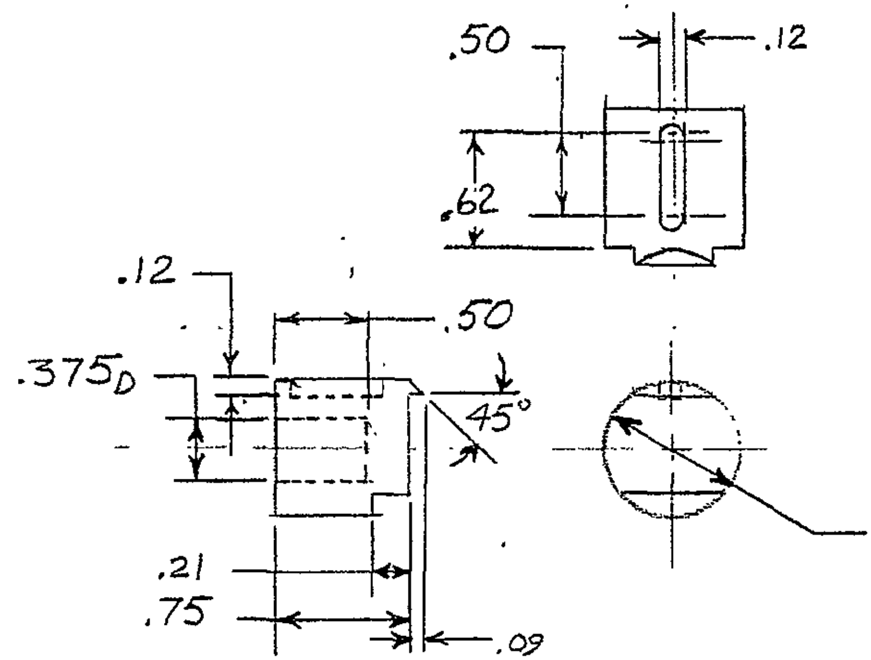
DIST TO

FN-901P (12-68) PRINTED IN U.S.A.

SIZE		SHEET	REV
A			

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON:

FRACTIONS	DECIMALS	ANGLES
±	±	±

ALL SURFACES ✓

MATL.

SIGNATURES		DAY	MO	YR
DRAWN	EJd	8	9	78
CHECKED				
ISSUED				
ENGRG				
MFG				
MATLS				

GENERAL ELECTRIC

DEPT LOC

LOCK FMS SAMPLE CANISTER

SIZE	CODE IDENT NO.	
A		SK15159-43

SCALE SHEET

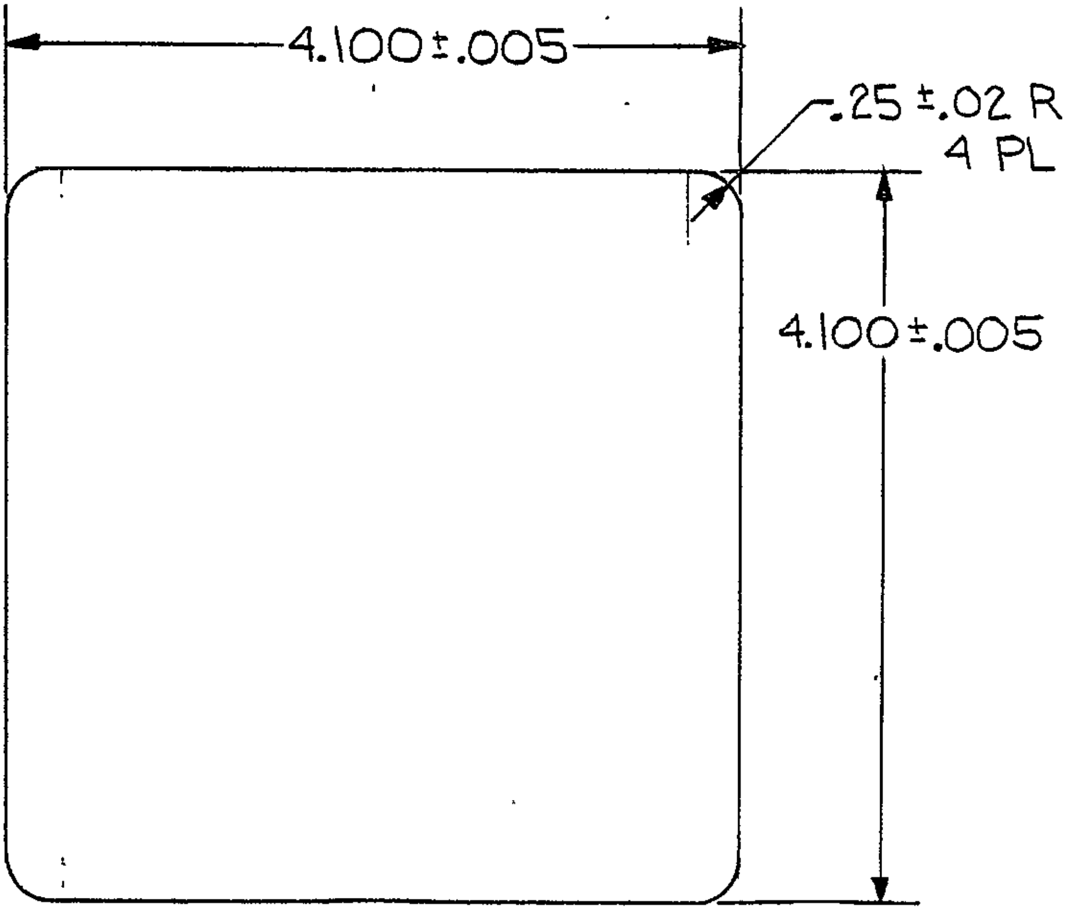
DIST TO

FN-901P (12-68) PRINTED IN U.S.A.

SIZE		SHEET	REV
A	SK-15159-39	1 OF 1	

REVISIONS

LTR.	DESCRIPTION	DATE	APPROVED



NOTES:

1. FINISH: TUFRAM COAT TYPE C22
   (.002 TOTAL THK. OF COATING)
   PER MIL-A-8625C TYPE III
   WITH TEFLON IMPREGNATION.
2. MAT'L TO BE .125 STOCK

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON:
FRACTIONS ± — DECIMALS ±.015 ANGLES ± —
ALL SURFACES 125 ✓

MATL.
AL ALLOY
6061-T6
SEE NOTES

SIGNATURES		DAY	MO	YR
DRAWN	P.P. Young	19	12	77
CHECKED				
ISSUED				
ENGRG				
MFG				
MATLS				

GENERAL ELECTRIC
SS DEPT LOC PHILA, PA

SAMPLE, SLIDE VALVE

SIZE	CODE IDENT NO.	
A	23991	SK-15159-39

SCALE 1/1 SHEET 1 OF 1

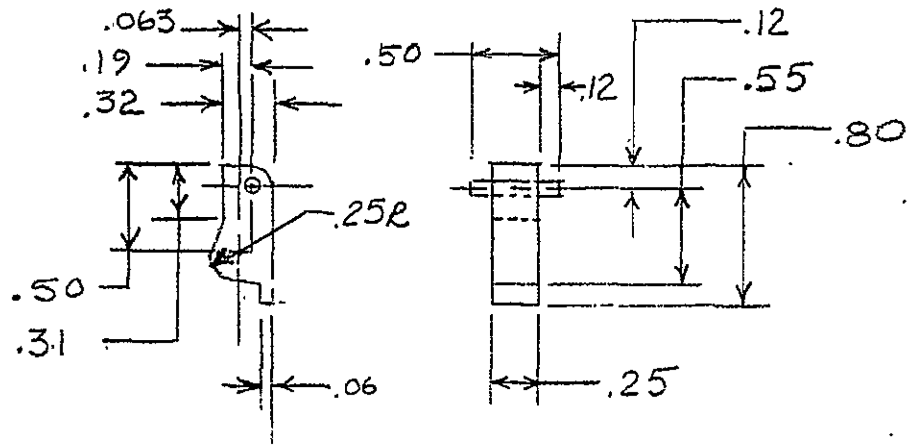
DIST TO

FN-901-F (9-64) REV PRINTED IN U.S.A.

SIZE A | SHEET | REV

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON:

FRACTIONS ± DECIMALS ± ANGLES ±

ALL SURFACES ✓

MATL-

SIGNATURES	DAY	MO	YR
DRAWN [illegible]	7	9	73
CHECKED			
ISSUED			
ENGRG			
MFG			
MATLS			

GENERAL ELECTRIC

DEPT LOC

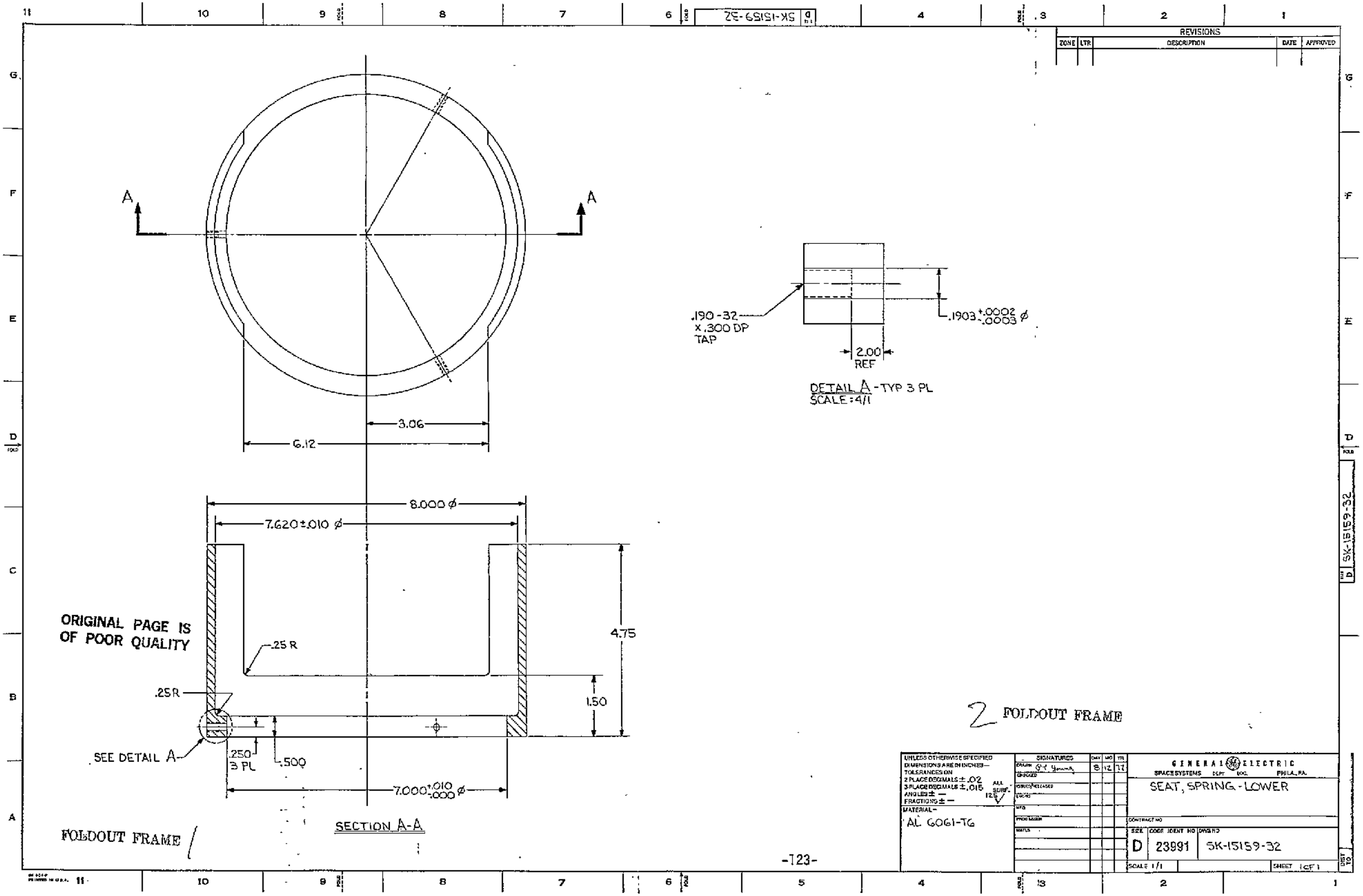
LOCK - SLIDE VALVE

SIZE A | CODE IDENT NO. | SK15159-66

SCALE | SHEET

DIST TO

FN-901P (12-66) PRINTED IN U.S.A.



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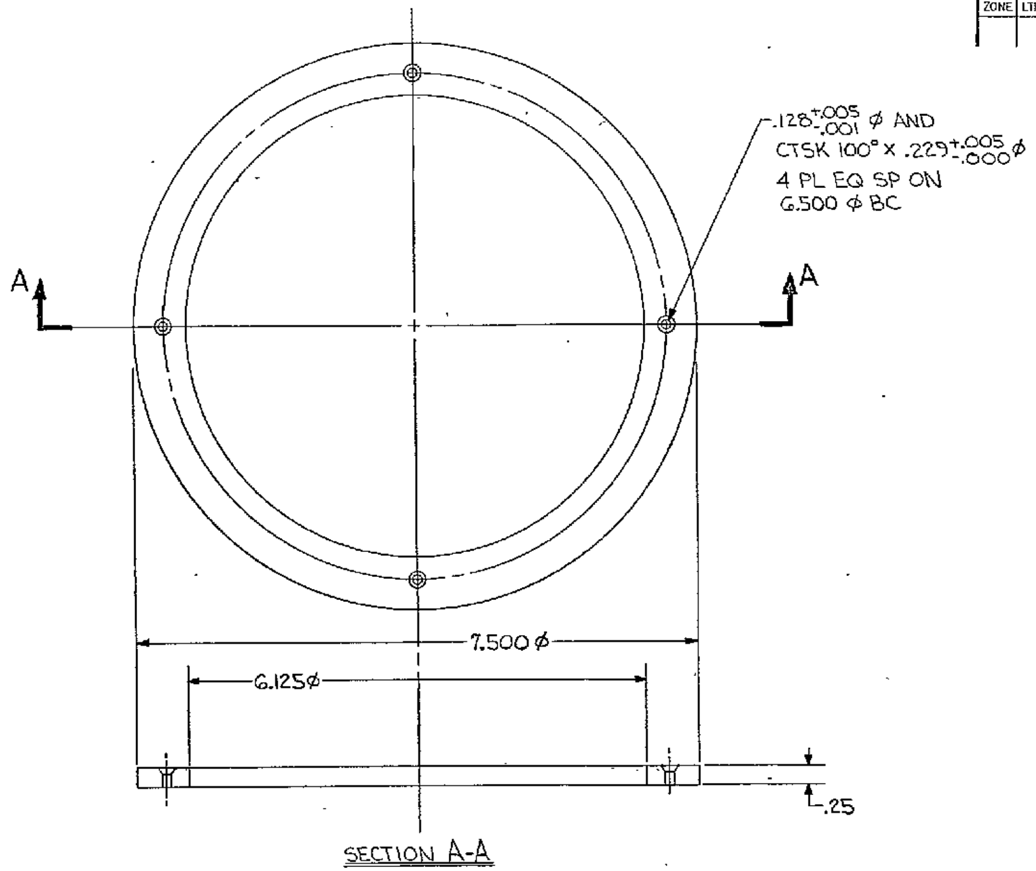
FOLDOUT FRAME 1

2 FOLDOUT FRAME

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED



2 FOLDOUT FRAME

FOLDOUT FRAME 1

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES—
TOLERANCES ON:
2-PLACE DECIMALS ± .02
3-PLACE DECIMALS ± .015
ANGLES ± 1°
FRACTIONS ± —
ALL SURF. 125√

MATERIAL—
AL 6061-T6

SIGNATURES		DAY	MO	YR
DRAWN	E.F. Young	7	12	77
CHECKED				
ISSUED				
ENGRG				
MFG				
MATLS				

GENERAL ELECTRIC
55 DEPT LOC. PHILA, PA

SEAT, SPRING - UPPER

SIZE	CODE IDENT NO.	
C	23991	SK-15159-30
SCALE 1/1		SHEET 1 OF 1

C SK-15159-30

FN-808-F (8-76) PRINTED IN U.S.A.

SIZE		SHEET
A	SK 56198 - 871	A

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED
A	CHANGED LOAD TO 60 AND 80 FROM 65 AND 85: REDUCED WIRE SIZE FROM .250 TO .225.	4/5/74	GLF

REQMTS:

OUTSIDE DIA. = 7.500 MAX.
INSIDE DIA. = 6.922 MIN.
SOLID HEIGHT = 1.250 MAX.
LOAD: 60 LBS AT 3.250 INCH COMPRESSED HEIGHT. 3.25
80 LBS AT 1.280 INCH COMPRESSED HEIGHT. 1.38
FREE LENGTH = 8.36 APPROX.
RIGHT OR LEFT HAND HELIX.
BOTH ENDS CLOSED AND GROUND SQUARE.
MATL: HIGH CARBON SPRING STEEL, 0.225 DIA.

ORIGINAL PAGE IS OF POOR QUALITY

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON:
FRACTIONS ± DECIMALS ± ANGLES ±
ALL SURFACES ✓
MATL

SIGNATURES		DAY	MO	YR
DRAWN	GLF	21	1	74
CHECKED				
ISSUED				
ENGRG				
MFG				
MATLS				

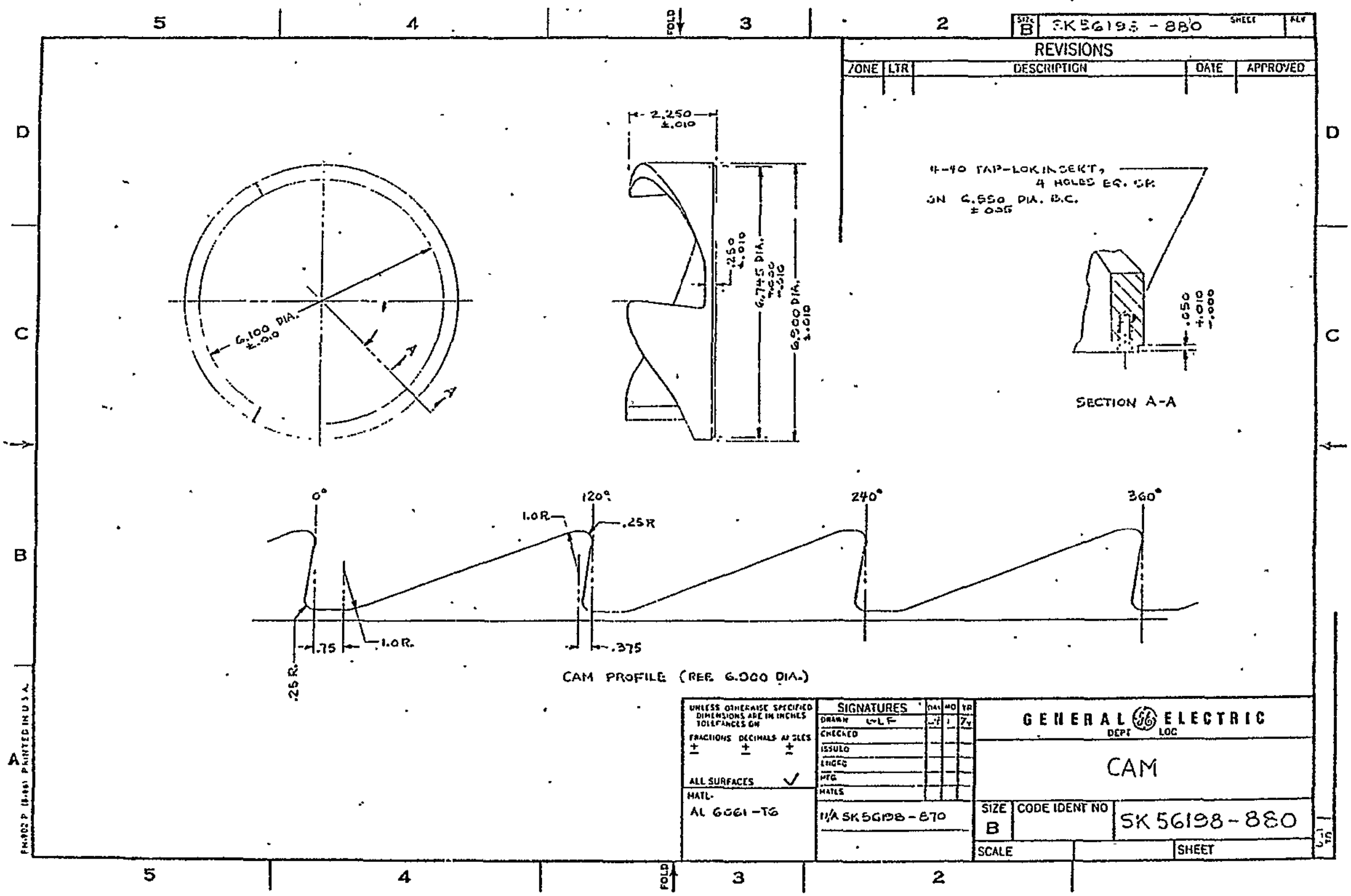
N/A SK 56198 - 870

GENERAL ELECTRIC
DEPT LCC

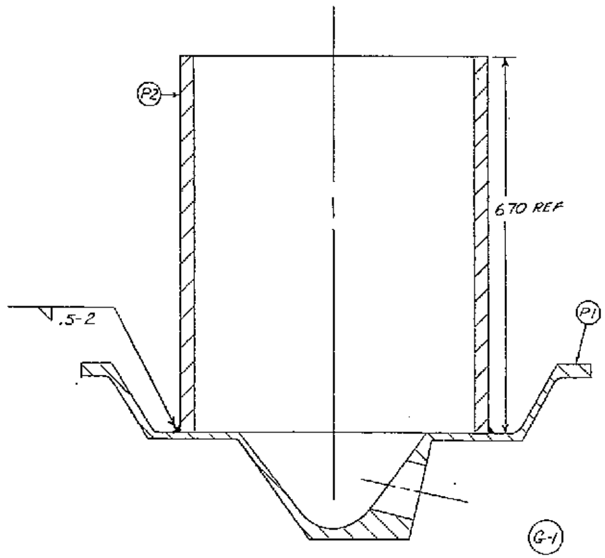
AXIAL MOTION
SPRING

SIZE	CODE IDENT NO.	
A		SK 56198 - 871

SCALE SHEET



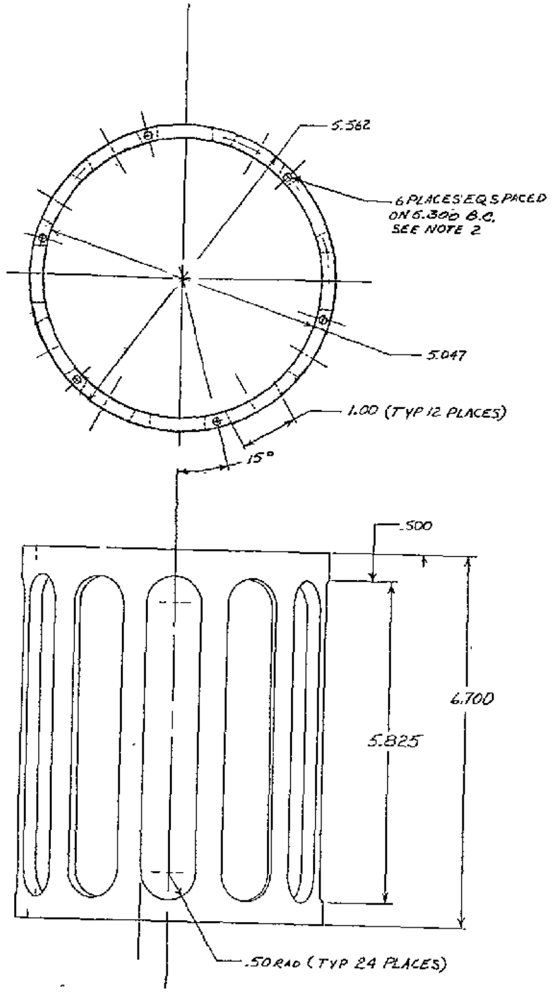
SK 56198 - 880
REVISIONS
ZONE | LTR | DESCRIPTION | DATE | APPROVED
2.250 ±.010
.250 ±.010
6.745 DIA. +.000 -.010
6.900 DIA. ±.010
6.100 DIA. ±.010
A
A
4-40 TAP-LOK INSERT, 4 HOLES EQ. SP. ON 6.550 DIA. B.C. ±.005
.050 +.010 -.000
SECTION A-A
0°
120°
240°
360°
1.0R.
.25R
.75
1.0R.
.375
.25R.
CAM PROFILE (REF. 6.000 DIA.)
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON
FRACTIONS ± DECIMALS ± ANGLES ±
ALL SURFACES ✓
MATL-
AL 6061-T6
SIGNATURES
DRAWN
CHECKED
ISSUED
ENGRG
MFG
MATLS
N/A SK 56198-870
GENERAL ELECTRIC
DEPT LOC
CAM
SIZE B
CODE IDENT NO
SK 56198-880
SCALE
SHEET



2 FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES— TOLERANCES ON 2 PLACE DECIMALS ± 3 PLACE DECIMALS ± ANGLES ± FRACTIONS ±	ALL SURF ✓	GENERAL ELECTRIC SPACE SYSTEMS DEPT PHILA., PA.
MATERIAL—		SLINGER HOUSING
SIZE D	CODE IDENT NO 23991	DWG NO SK 15159-62
SCALE		SHEET

FOLDOUT FRAME



NOTES:

1. INTERPRETATION OF DWG TERMS AND TOLERANCES PER 530009
2. INSTALL INSERTS PER MS 33537-28 USING SUPER KORO PON (CALCIUM CHROMATE) PRIMER, PER GE SVS 9702 (INSERT No. MS 21209-C0615

FOLDOUT FRAME 2

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES — TOLERANCES ON
2 PLACE DECIMALS ±
3 PLACE DECIMALS ± .005 ALL SURF. √
ANGLES ±
FRACTIONS ±

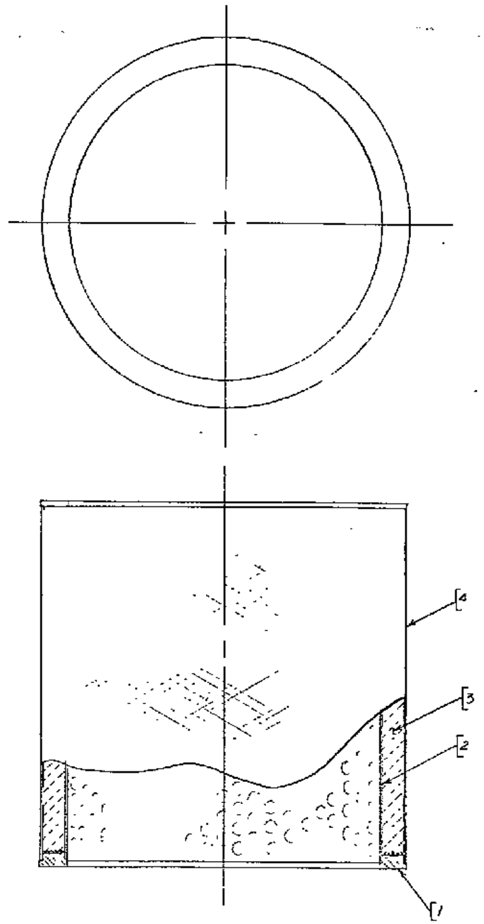
MATERIAL — 6061-T6 ALUM MAKE FROM 5" IPS ALUM PIPE

GENERAL ELECTRIC SPACE SYSTEMS PHILA., PA.

FILTER SUPPORT

SIZE D | CODE IDENT NO 23991 | DWG NO SK15159-61

FOLDOUT FRAME 1



(G1)

FOLDOUT FRAME

2 FOLDOUT FRAME

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES—
TOLERANCES ON.
2 PLACE DECIMALS ±
3 PLACE DECIMALS ±
ANGLES ±
FRACTIONS ±
ALL SURF. ✓
MATERIAL —

SIGNATURES	DAY	MO	YR
DRAWN			
CHECKED			
ISSUED/RELEASED			
ENGRG			
MFG			
PROD ASSUR			
MATLS			

GENERAL ELECTRIC
SPACE SYSTEMS DEPT LOC. PHILA., PA.

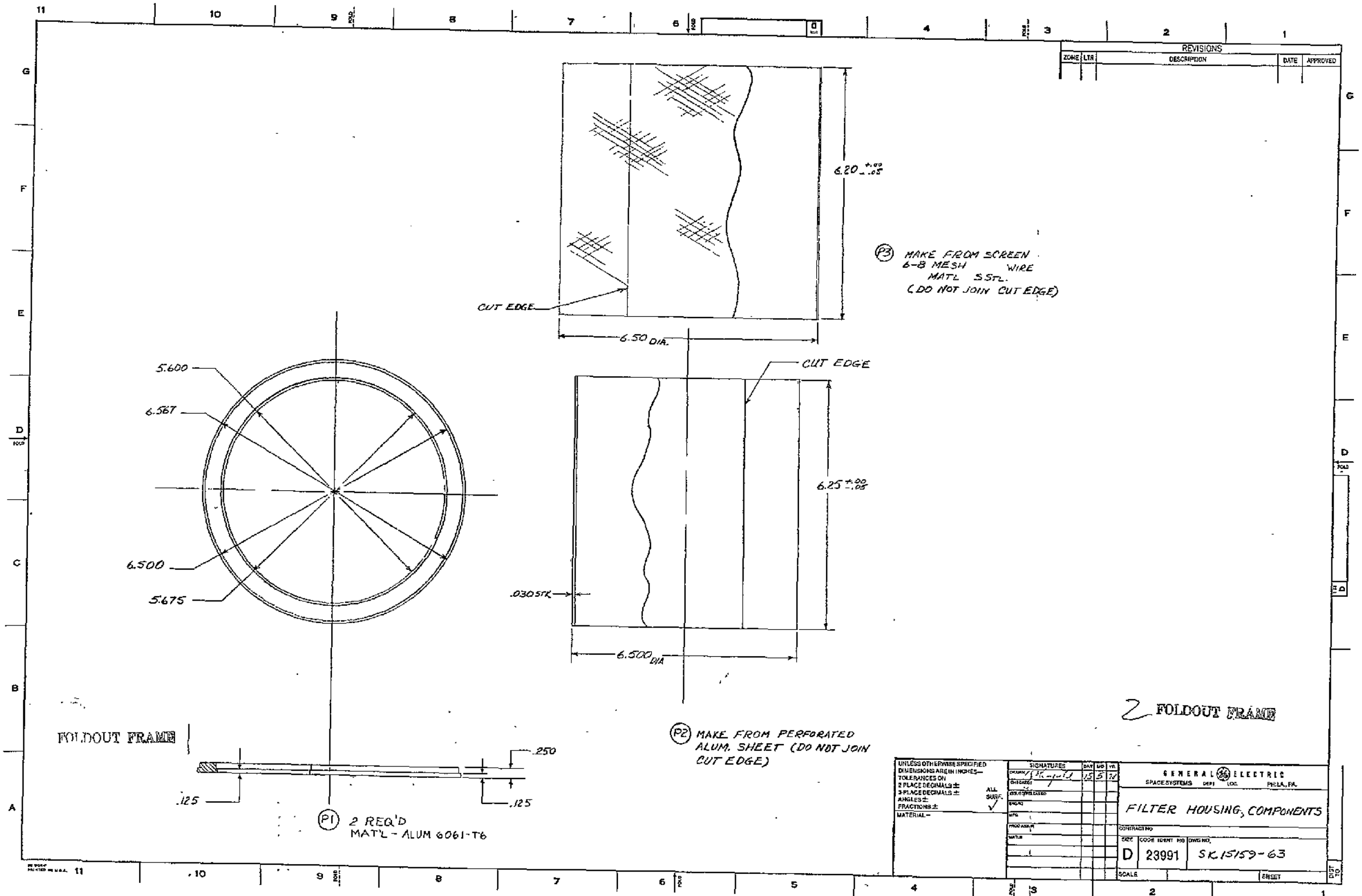
FILTER, DEBRIS, BACTERIA

CONTRACT NO

SIZE	CODE IDENT NO	DWG NO
D	23991	SK15159 - 69

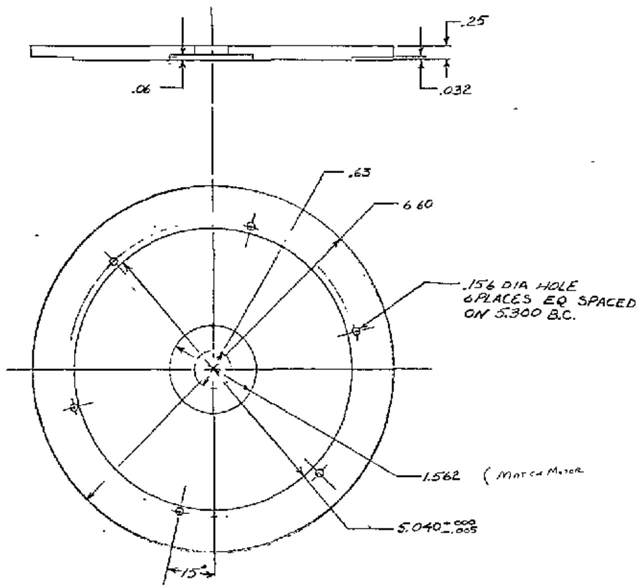
SCALE SHEET

DIST TO


REVISIONS
ZONE
LTR
DESCRIPTION
DATE
APPROVED
6.20
CUT EDGE
6.50 DIA.
(P3) MAKE FROM SCREEN
6-8 MESH WIRE
MATL SSTL.
(DO NOT JOIN CUT EDGE)
5.600
6.567
6.500
5.675
CUT EDGE
6.25
.030 STK.
6.500 DIA
(P2) MAKE FROM PERFORATED
ALUM. SHEET (DO NOT JOIN
CUT EDGE)
FOLDOUT FRAME
.250
.125
.125
(P1) 2 REQ'D
MAT'L - ALUM 6061-T6
FOLDOUT FRAME
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES—
TOLERANCES ON
2 PLACE DECIMALS ±
3-PLACE DECIMALS ±
ANGLES ±
FRACTIONS ±
ALL SURF.
MATERIAL—
SIGNATURES
DAY
MO
YR
15
5
71
GENERAL ELECTRIC
SPACE SYSTEMS
PHILA., PA.
FILTER HOUSING, COMPONENTS
CONTRACT NO
SIZE
CODE IDENT NO
DWG NO.
D
23991
SK15159-63
SCALE
SHEET

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED



Z FOLDOUT FRAME

FOLDOUT FRAME

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES—
TOLERANCES ON
2 PLACE DECIMALS ±
3 PLACE DECIMALS ±
ANGLES ±
FRACTIONS ±
MATERIAL—

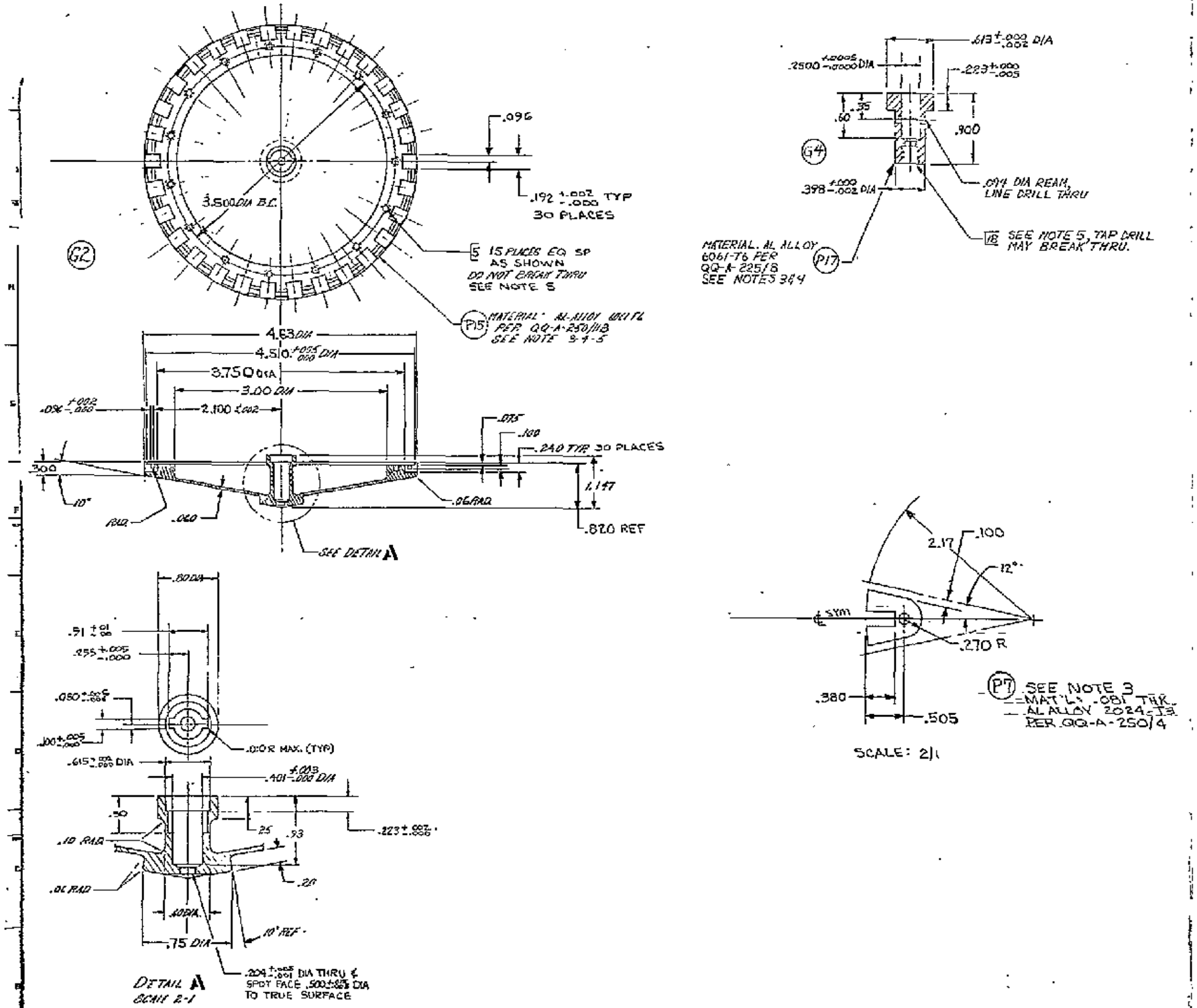
ALL SURF √

GENERAL ELECTRIC
SPACE SYSTEMS PHILA., PA.

MOUNTING SLINGER MOTOR

SIZE D CODE IDENT NO 23991 DWG NO SK15159-64

2 FOLDOUT FRAME



NOTES-
1 TERMS & TOL PER S 30009

3. FINISH TUFRAM * COATING TYPE C22 PER MIL-A-8625C, TYPE III WITH TEFLON IMPREGNATION - DO NOT COAT TAPPED HOLES OR THREADS
* TUFRAM IS A PROPRIETARY PROCESS OF GENERAL MAGNAPLATE CORP LINDEN, N.J.
4. FINISH TAPPED HOLES AFTER COATING WITH ALODINE 600 PER 171A4223 TYI
5. INSTALL INSERTS PER MS 33537-28 - INSTALL USING SUPER KOROPON (CALCIUM CHROMATE) PRIMER, PER G.E. SYS-9702 REMOVE TANG AFTER ASSY
6. TEFLON COAT P9 & P10 AFTER WELDING PER J71A4771 TYI.
7. WELD PER 146A9614 CLASS IV.

9. ALL DIMENSIONS APPLY AFTER COATING PER NOTE 3.
10. HEAT TREAT P10 TO FULL SPRING CONDITION PER MIL-H-6875.
11. TORQUE REQUIREMENTS:

BOLT SIZE	TORQUE
#4-40	5-6 IN-LB

REDUCED SIZE PRINT
SCALE 0 1 2 INCHES

G4	G3	G2	G1	IDENTIFICATION NO.	ITEM NO.	DESCRIPTION
			15	AN960PD4L	20	WASHER #4
			15	MS51957-13	19	SCREW #4-40
1				MS21209-C0815	18	INSERT 8-32 UNC
1				SK-15159-34P17	17	BUSHING
		1		SK-15159-34P15	15	WHEEL
	1			MS16555-620	13	DOWEL PIN 3/32 DIA X .310 LG.
	1			TO14-80-107	12	SPRING, TORSION
	1			SK-15159-34P10	10	TINE, SWINGING
	1			SK-15159-34P9	9	BLOCK, SWING
					8	
			15	SK-15159-34 P7	7	RETAINING PLATE
					6	
		15		MS21209C0410	5	INSERTS 4-40 UNC
X				SK-15159-34G4	4	BUSHING ASSY.
	X		30	SK-15159-34G3	3	TINE, SWINGING ASSY.
		X	1	SK-15159-34G2	2	WHEEL ASSY
			X	SK-15159-34 G1	1	SLINGER ASSY

QTY REQUIREMENTS PER ASSY — LIST OF MATERIAL

REVISION STATUS TABULATION

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON 2 PLACE DECIMALS ± .02 3 PLACE DECIMALS ± .005 ANGLES ± 0° 05'

SEE F/D

GENERAL ELECTRIC S.E. PHILA PA

SLINGER WHEEL ASS'Y

E 23991 SK-15159-34

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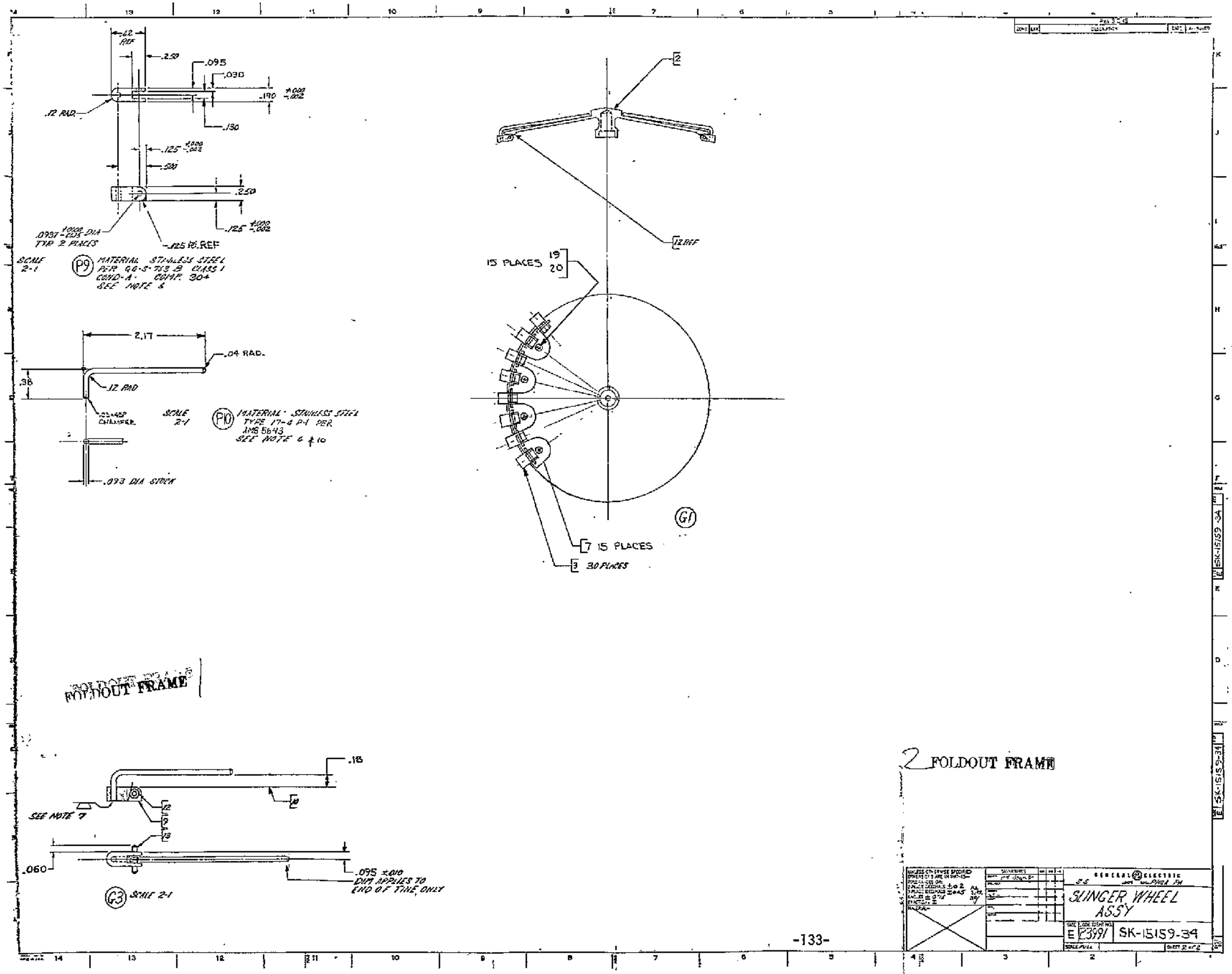
FOLDOUT FRAME



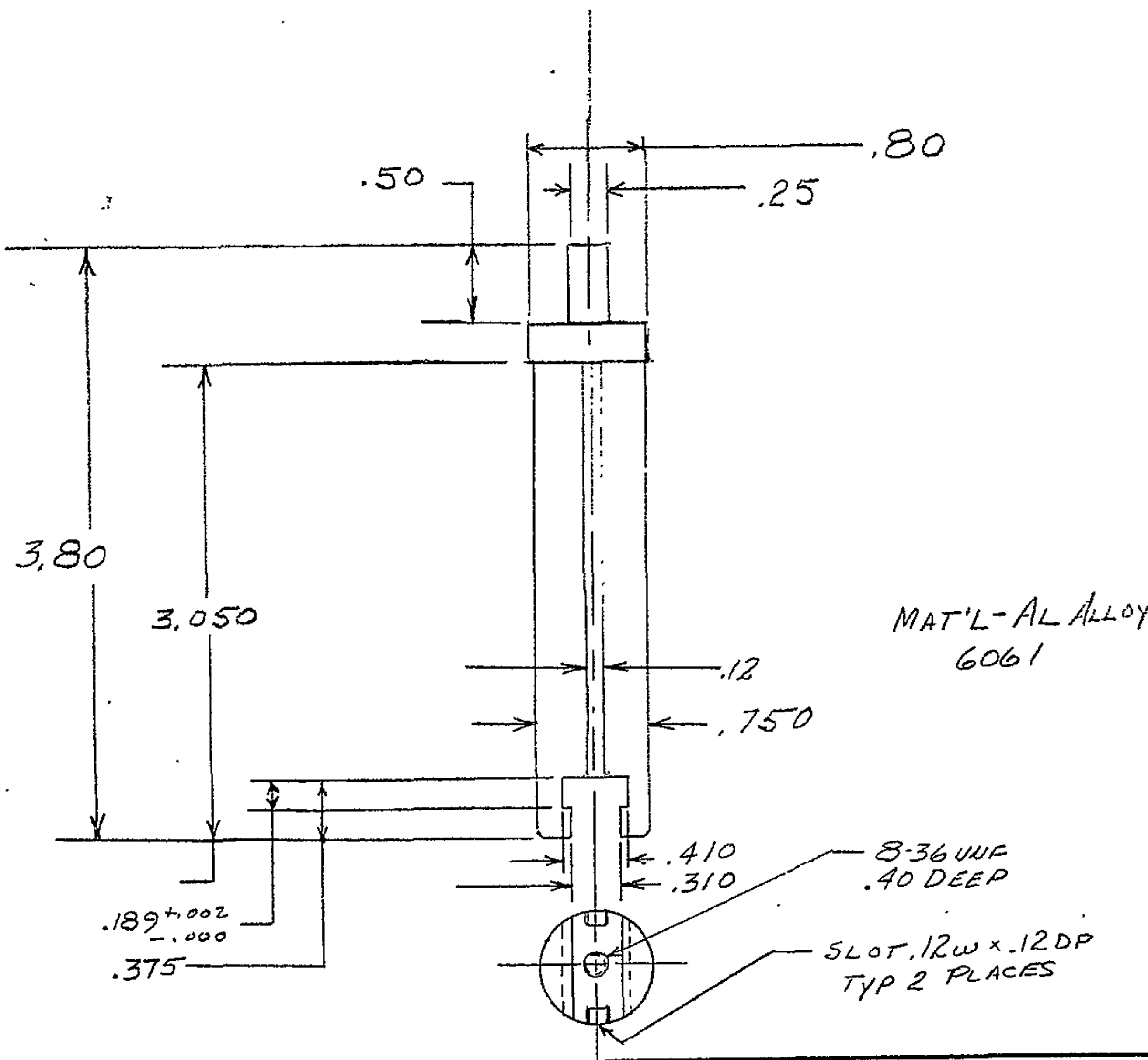
FOLDOUT FRAME

2 FOLDOUT FRAME

SIZE A		SHEET	REV

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED



MAT'L - AL ALLOY 6061

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON:

FRACTIONS ± DECIMALS ± ANGLES ±

ALL SURFACES ✓

MATL-

SIGNATURES	DAY	MO	YR
DRAWN			
CHECKED			
ISSUED			
ENGRG			
MFG			
MATLS			

GENERAL ELECTRIC

DEPT LOC

FMS SAMPLE CANISTER HANDLE

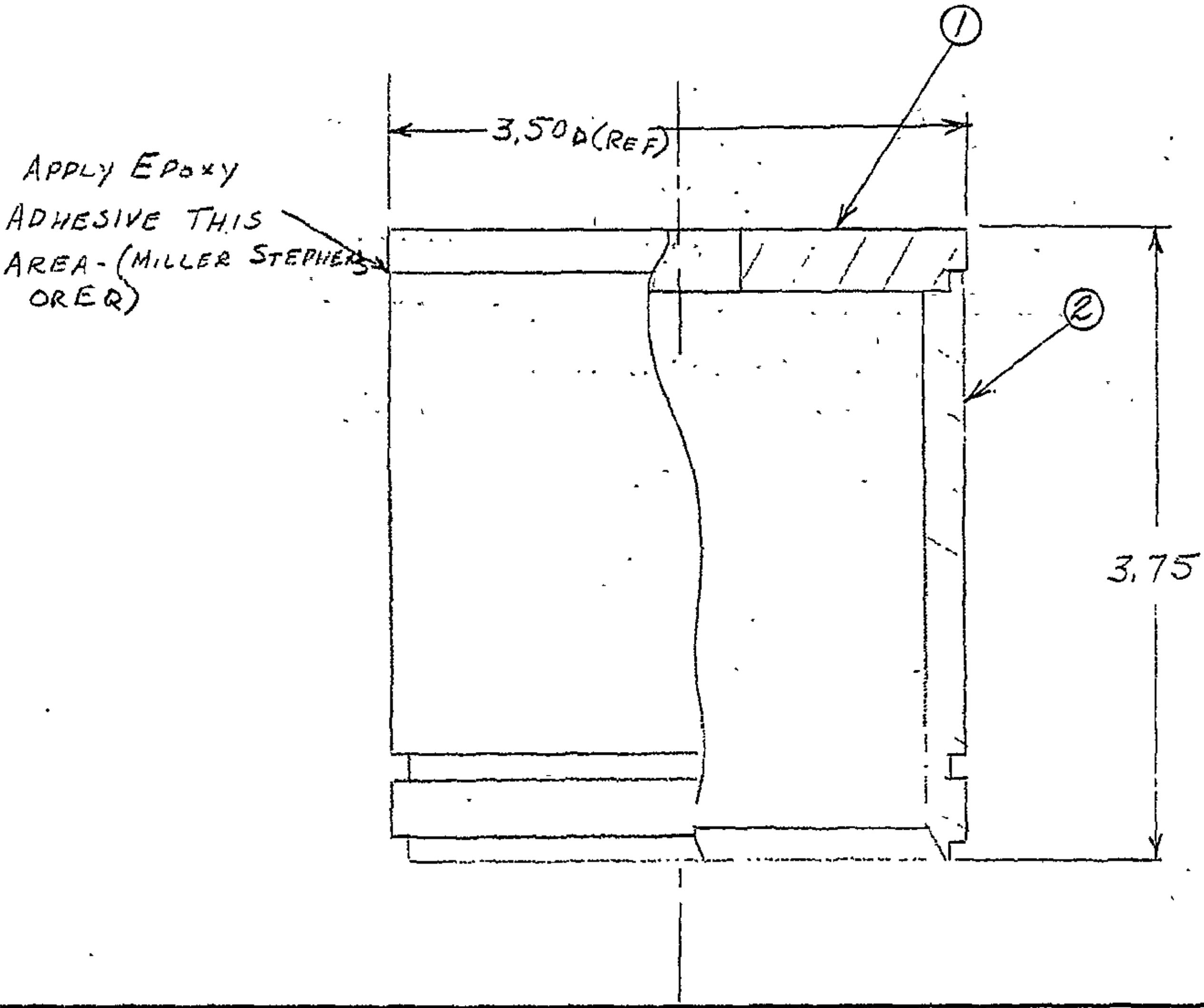
SIZE	CODE IDENT NO.	
A		SK 15159-42
SCALE		SHEET

DIST TO

FN-901P (12-68) PRINTED IN U.S.A.

SIZE A		SHEET	REV

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON:	SIGNATURES	DAY	MO	YR	GENERAL ELECTRIC
FRACTIONS ± DECIMALS ± ANGLES ±	DRAWN				DEPT LOC
	CHECKED				
	ISSUED				FMS SAMPLE CANISTER TUBE ASSY
	ENGRG				
ALL SURFACES ✓	MFG				
MATL-	MATLS				
					SIZE A · CODE IDENT NO. · SK15159 - 47
					SCALE · SHEET

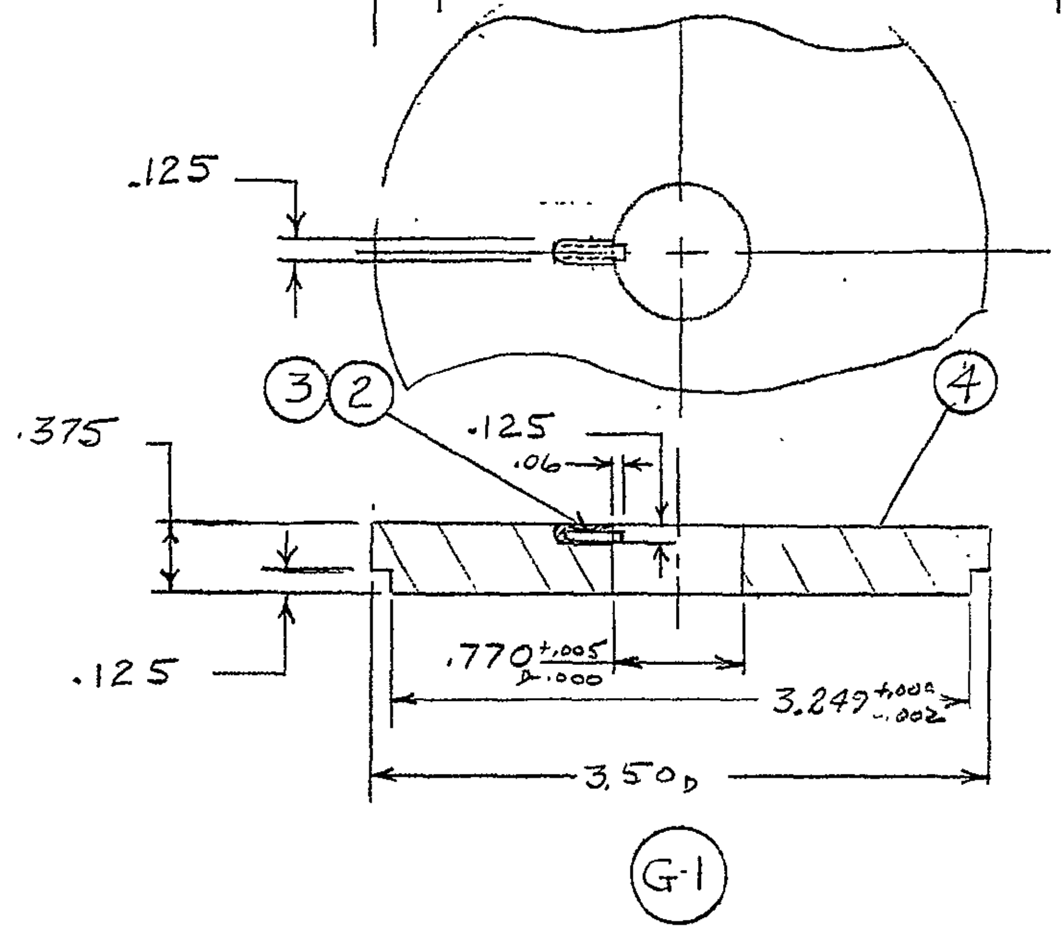
FN-901P (12-68) PRINTED IN U.S.A.

DIST TO

SIZE	SHEET	REV
A		

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED



ORIGINAL PAGE IS
OF POOR QUALITY

FOLDOUT FRAME

4	COVER-(MATL AL.ALLOY)
3	EPOXY (MILLER-STEPHENSON E a
2	PIN-(S STL .06D x .375)
G-1	ASSEMBLY
PART No	DESCRIPTION

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON: FRACTIONS ± DECIMALS ± ANGLES ±	SIGNATURES	DAY	MO	YR
	DRAWN	9	5	78
	CHECKED			
	ISSUED			
ALL SURFACES ✓	ENGRG			
MATL-	MFG			
	MATLS			

GENERAL ELECTRIC

DEPT LOC

FMS SAMPLE CANISTER COVER ASSY

SIZE	CODE IDENT NO.	
A		SK15159-45
SCALE		SHEET

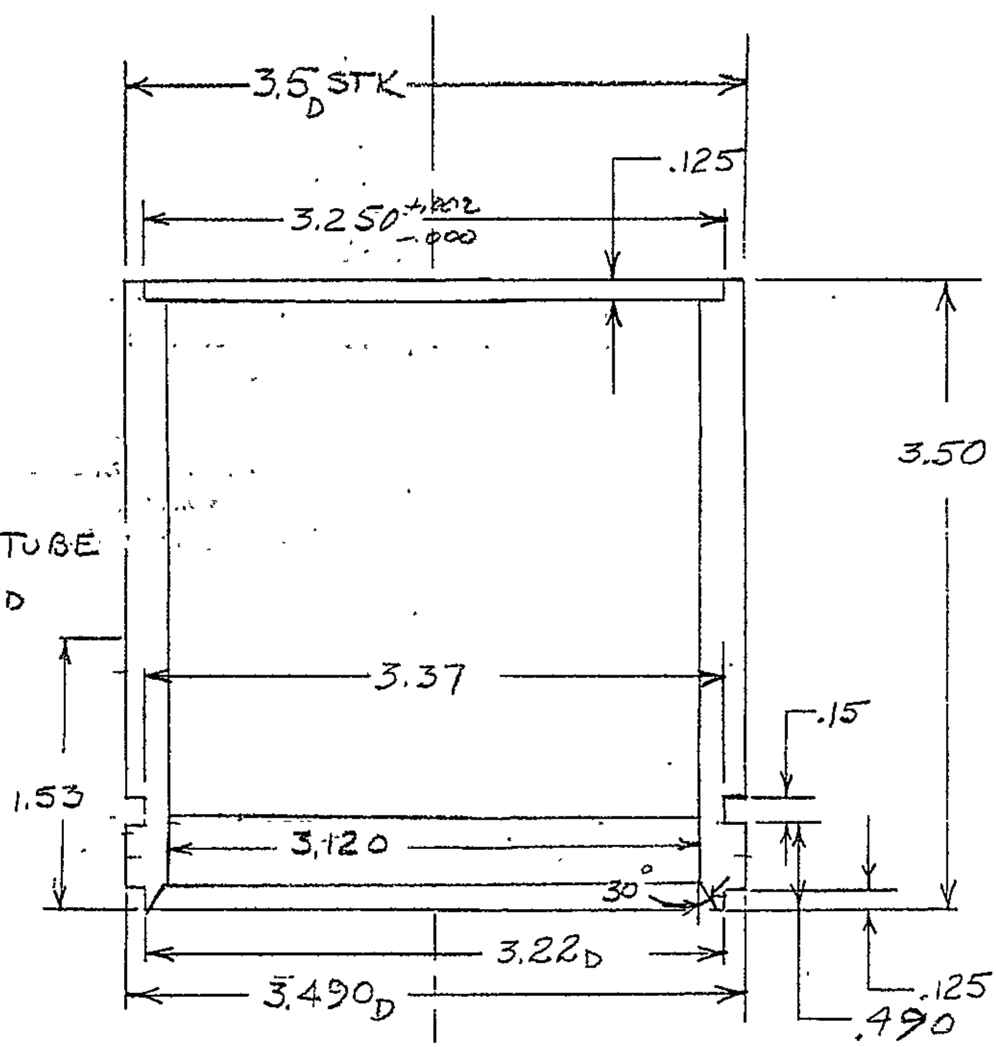
DIST TO

FN-901P (12-68) PRINTED IN U.S.A.

SIZE		SHEET	REV
A			

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED



MAKE FROM
CAST ACRYLIC TUBE
3.5" OD x 3.0" ID

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON: FRACTIONS ± DECIMALS ± ANGLES ±	SIGNATURES	DAY	MO	YR	GENERAL ELECTRIC DEPT LOC
	DRAWN EJC	9	9	78	
	CHECKED				FMS SAMPLE CANISTER TUBE
	ISSUED				
	ENGRG				
ALL SURFACES ✓	MFG				
MATL-	MATLS				

SIZE	CODE IDENT NO.	
A		SK-15159-67
SCALE		SHEET

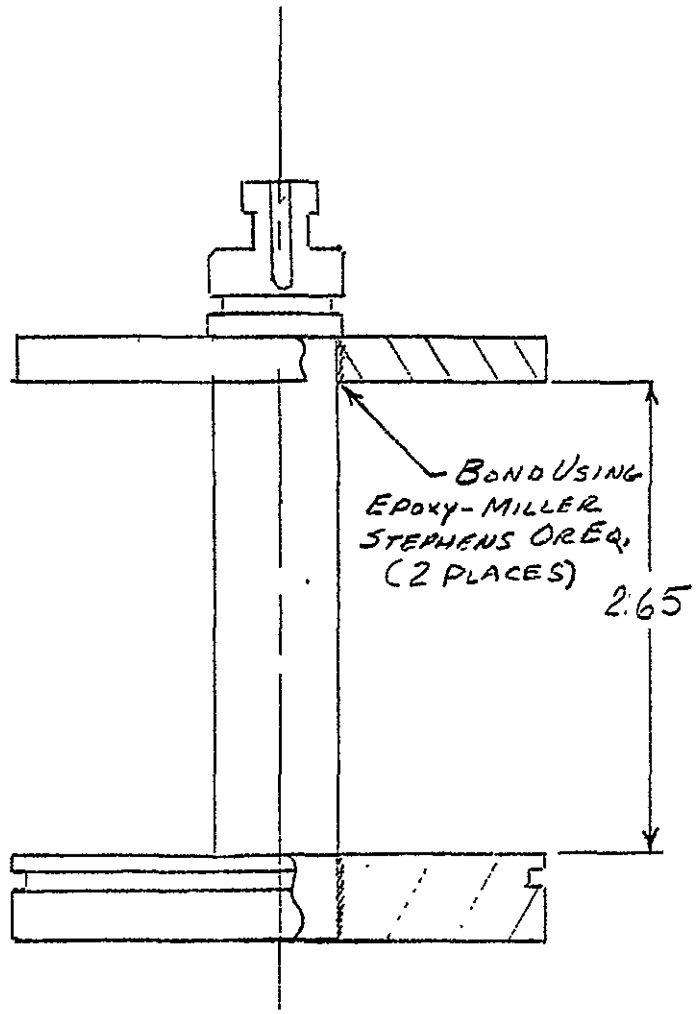
DIST TO:

FN-901P (12-68) PRINTED IN U.S.A.

SIZE A		SHEET	REV

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON:

FRACTIONS ± DECIMALS ± ANGLES ±

ALL SURFACES ✓

MATL- 6061 AL

SIGNATURES	DAY	MO	YR
DRAWN			
CHECKED			
ISSUED			
ENGRG			
MFG			
MATLS			

GENERAL ELECTRIC

DEPT LOC.

FMS SAMPLE CANISTER SPOOL ASSY

SIZE	CODE IDENT NO.	
A		SK 15159-46
SCALE		SHEET

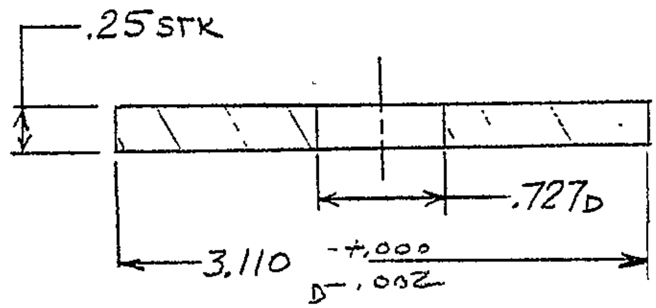
DIST TO

FN-901P (12-68) PRINTED IN U.S.A.

SIZE A		SHEET	REV

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON:
FRACTIONS ± DECIMALS ± ANGLES ±
ALL SURFACES ✓
MATL. Alum Alloy 6061

SIGNATURES	DAY	MO	YR
DRAWN EJC	9	9	78
CHECKED			
ISSUED			
ENGRG			
MFG			
MATLS			

GENERAL ELECTRIC
DEPT LOC.

FMS SAMPLE CANISTER SPOOL TOP

SIZE A | CODE IDENT NO. | SK 15152-44
SCALE | | SHEET

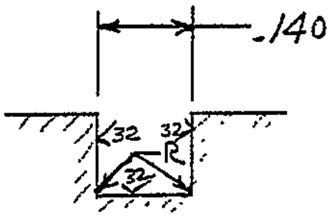
DIST TO

FN-901P (12-68) PRINTED IN U.S.A.

SIZE	SHEET	REV
A		

REVISIONS

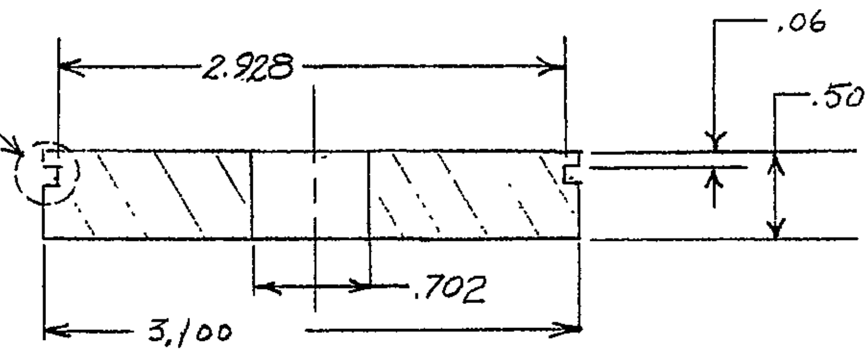
LTR	DESCRIPTION	DATE	APPROVED



MAT'L- AL ALLOY (6061

SEE DETAIL A

USE O-RING #2-150



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON: FRACTIONS ± DECIMALS ± ANGLES ±	SIGNATURES	DAY	MO	YR	GENERAL ELECTRIC DEPT LOC
	DRAWN EJ	9	9	70	
	CHECKED				FMS SAMPLE CANISTER SPOOL BASE
	ISSUED				
	ENGRG				
ALL SURFACES ✓	MFG				
MATL-	MATLS				

SIZE	CODE IDENT NO.	
A		SK 15159-70
SCALE		SHEET

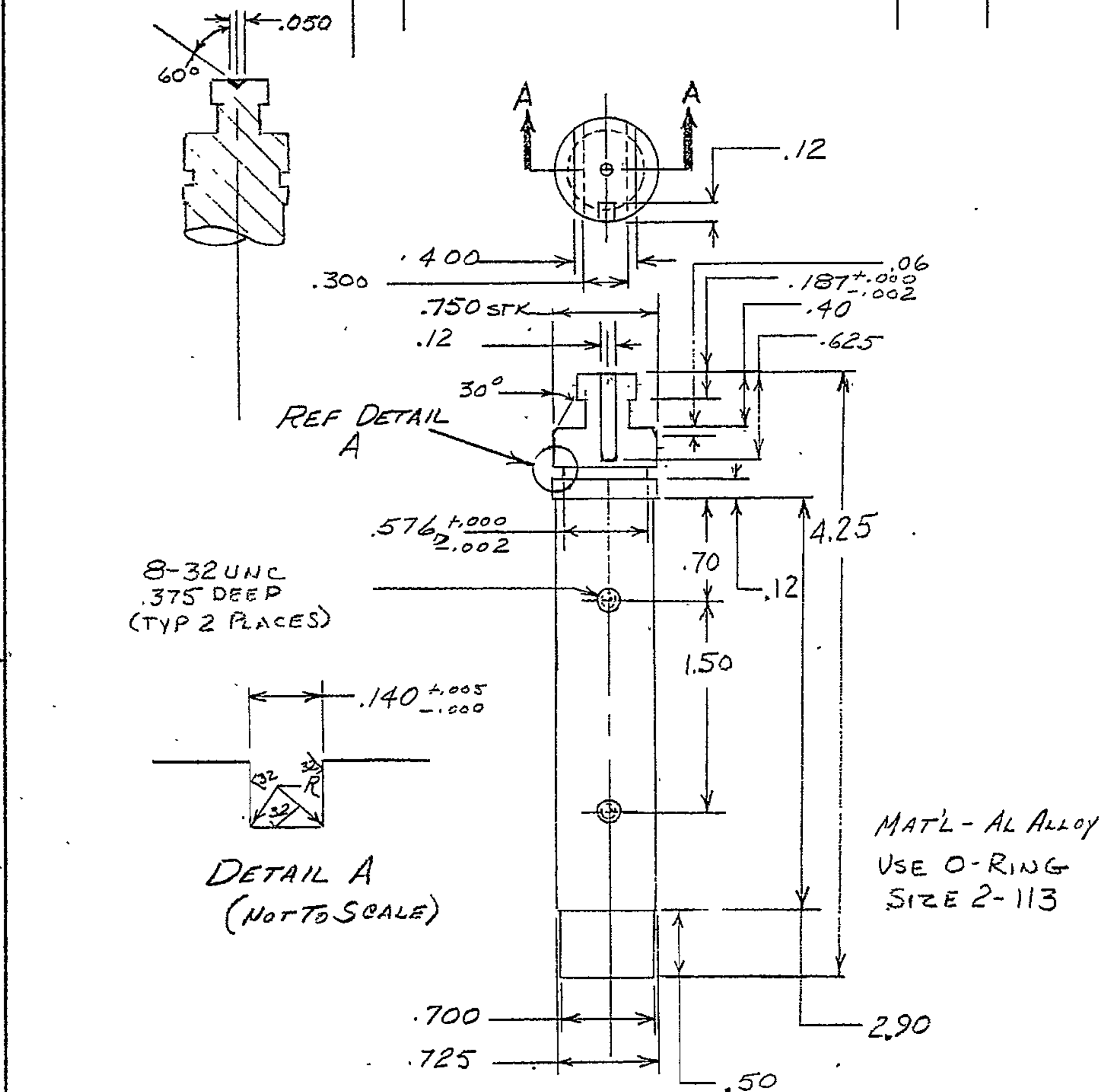
DIST TO

FN-901P (12-65) PRINTED IN U.S.A.

SIZE A		SHEET	REV

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON:	SIGNATURES	DAY	MO	YR	GENERAL ELECTRIC
FRACTIONS ± DECIMALS ± ANGLES ±	DRAWN [illegible]	9	9	78	DEPT LOC
	CHECKED				FMS SAMPLE CANISTER SHAFT
	ISSUED				
	ENGRG				
ALL SURFACES ✓	MFG				
MATL-	MATLS				
					SIZE A / CODE IDENT NO. / SK 15159-68
					SCALE / SHEET

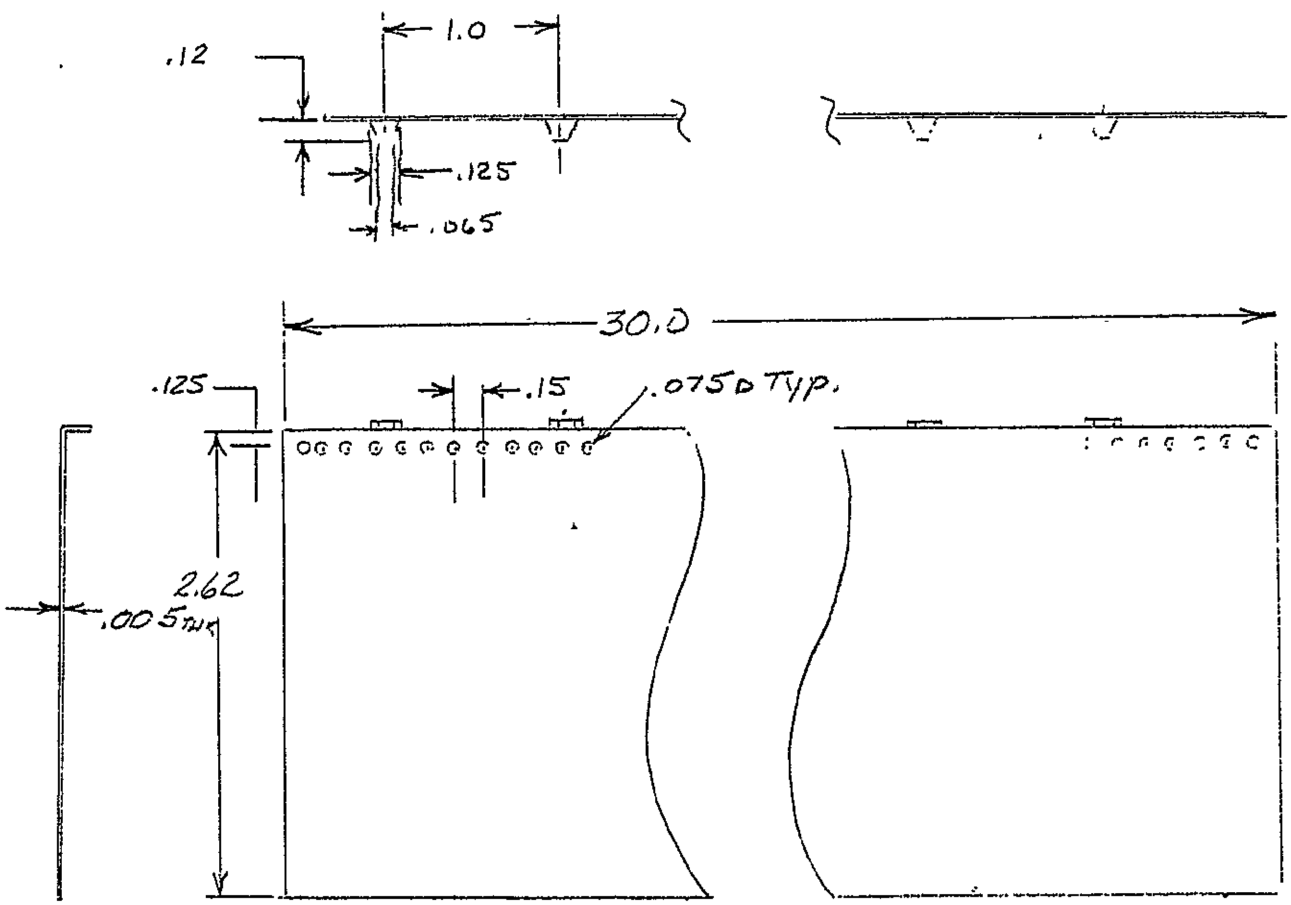
DIST TO

FN-901P (12-68) PRINTED IN U.S.A.

SIZE		SHEET	REV
A			

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED



MAKE FROM .005" THICK
SSTL SHIM STOCK

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON:	SIGNATURES	DAY	MO	YR
FRACTIONS ± DECIMALS ± ANGLES ±	DRAWN			
	CHECKED			
	ISSUED			
	ENGRG			
ALL SURFACES ✓	MFG			
MATL. STAINLESS STEEL SHIM STOCK.	MATLS			

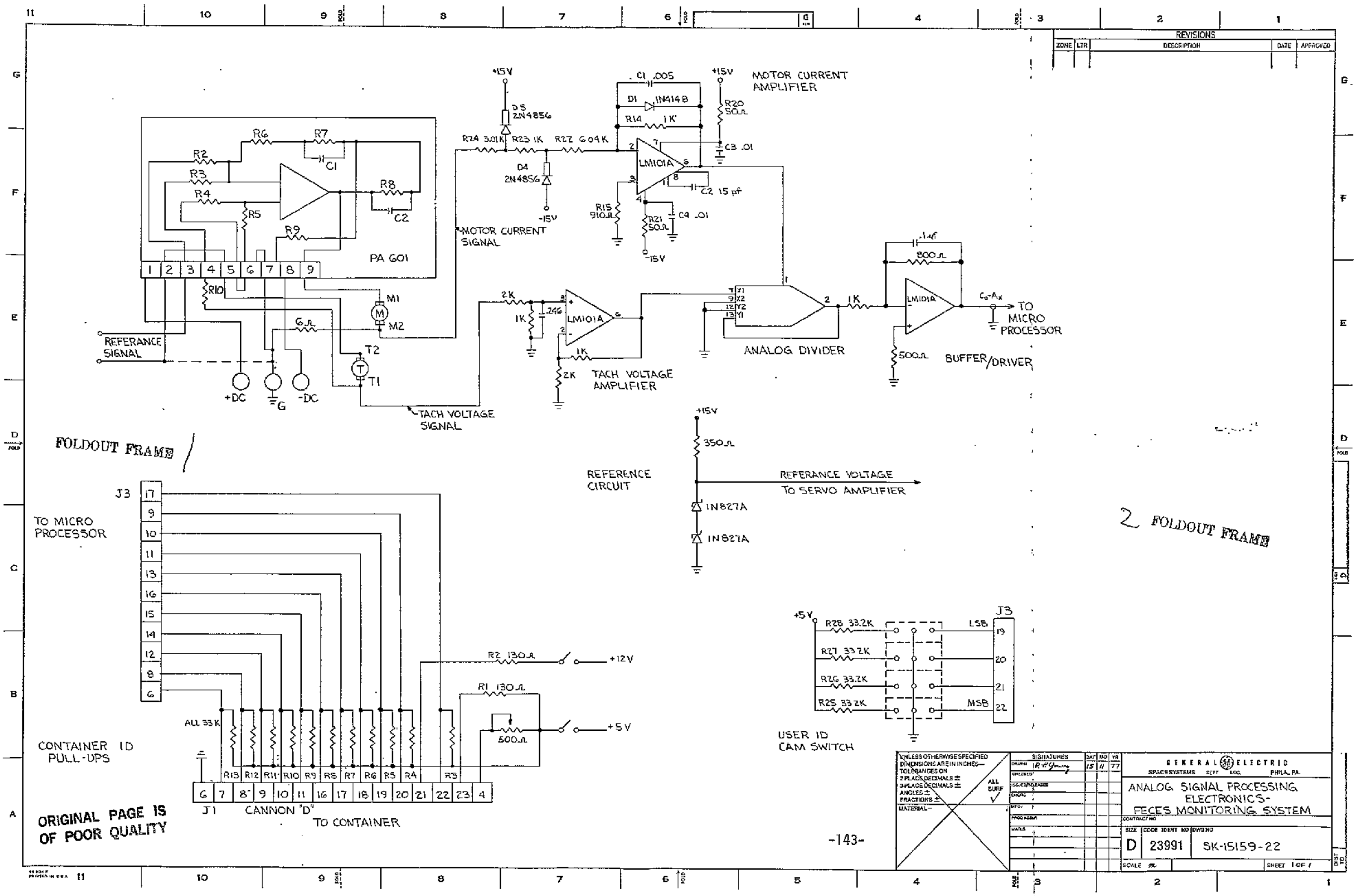
GENERAL ELECTRIC

DEPT LOC

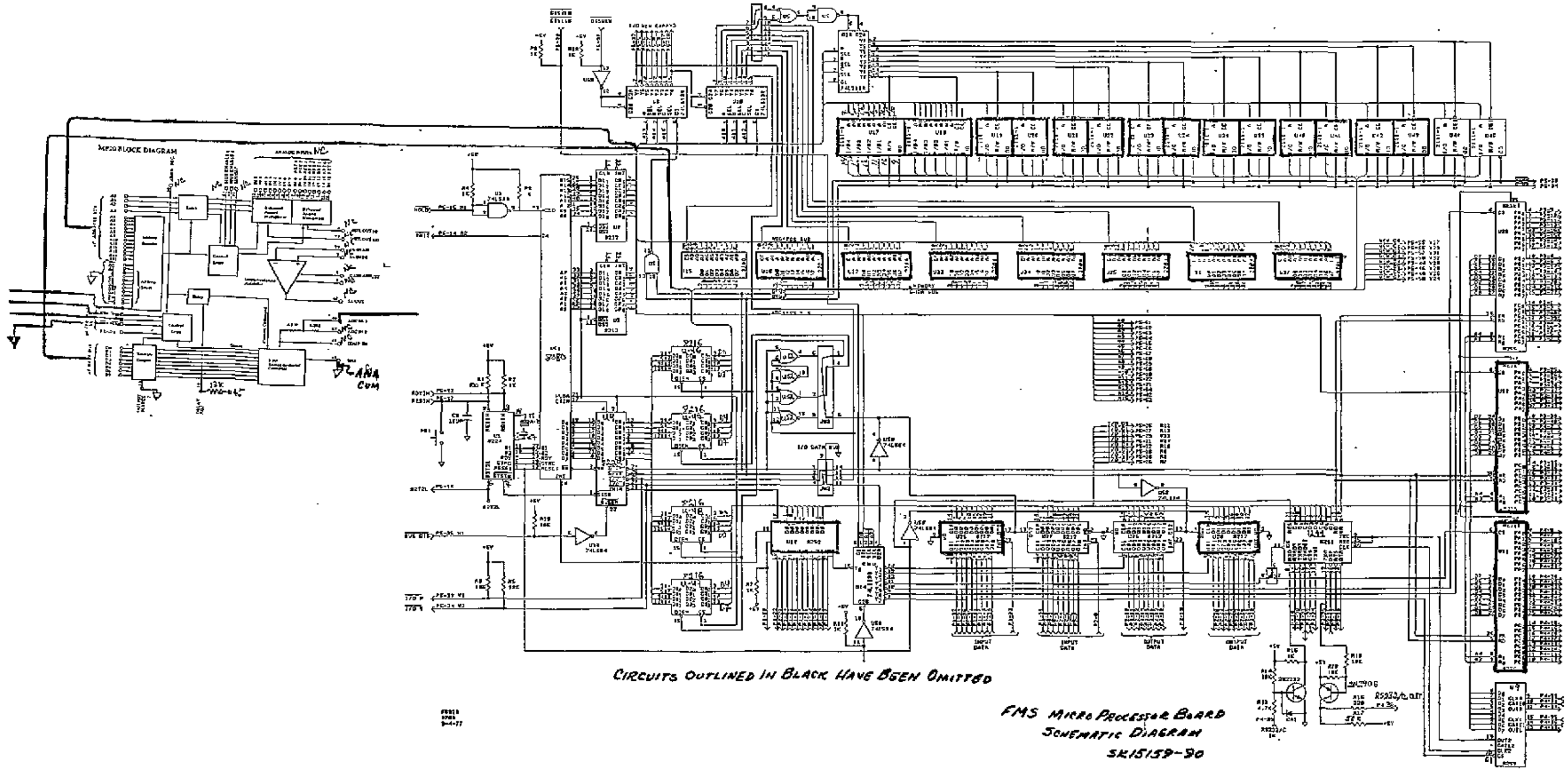
FMS SAMPLE STRIP

SIZE	CODE IDENT NO.	
A		SK15159-65

SCALE		SHEET	DIST TO



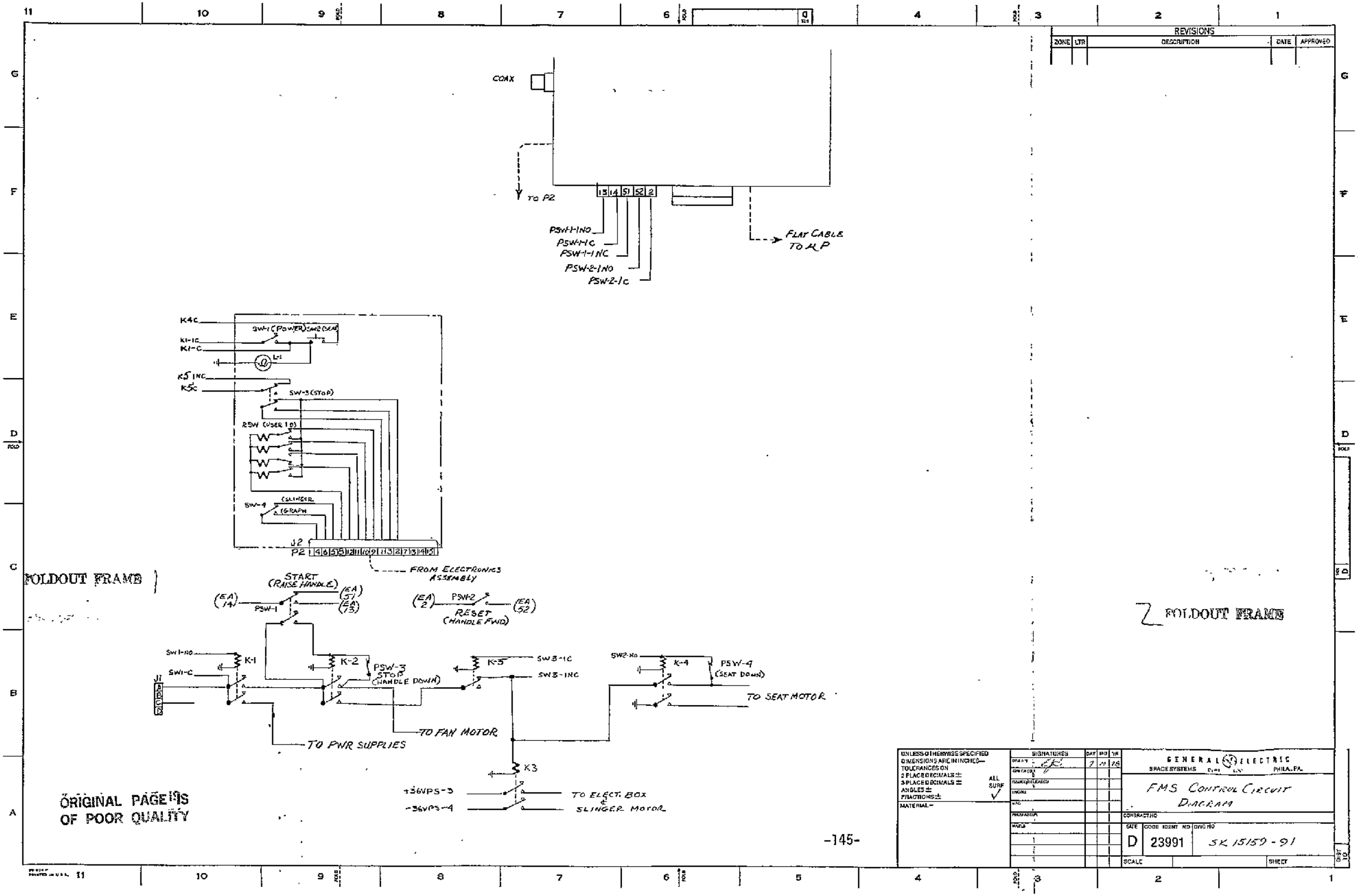
MOTOR CURRENT AMPLIFIER
LM101A
PA G01
MOTOR CURRENT SIGNAL
REFERANCE SIGNAL
+DC
G
-DC
TACH VOLTAGE SIGNAL
TACH VOLTAGE AMPLIFIER
ANALOG DIVIDER
BUFFER/DRIVER
TO MICRO PROCESSOR
REFERENCE CIRCUIT
REFERANCE VOLTAGE TO SERVO AMPLIFIER
1N827A
FOLDOUT FRAME
TO MICRO PROCESSOR
J3
CONTAINER ID PULL-UPS
ALL 33K
J1 CANNON "D" TO CONTAINER
USER ID CAM SWITCH
LSB
MSB
2 FOLDOUT FRAME
ORIGINAL PAGE IS OF POOR QUALITY
GENERAL ELECTRIC SPACE SYSTEMS PHILA. PA.
ANALOG SIGNAL PROCESSING ELECTRONICS-FECES MONITORING SYSTEM
D 23991 SK-15159-22
SHEET 1 OF 1
REVISIONS



FOLDOUT FRAME

ORIGINAL PAGE IS
OF POOR QUALITY

2 FOLDOUT FRAME



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APPENDIX D

DATA ANALYSIS METHODS AND DATA FOR FMS PERFORMANCE TESTING

DATA ANALYSIS METHODS

Reduction and analysis of the FMS test data was accomplished using the Statistical Analysis System II (STATII***) of the General Electric Mark III Computer.

Data files were established for each test. These files contained the mass of the samples inputted to the FMS and the FMS output for the sample mass.

STATII*** was then invoked and the data from the test files was read into the system and sorted to order the data from the smallest to the largest sample size. Following this, a Statistical Analysis Routine (CURV) was employed to determine values for the best fit linear regression formula of the form Y = A + B * X where X = FMS output for mass and Y is the CURV determined estimated mass (MASSEST). The MASSEST value is provided by inputting the FMS output for mass into the regression formula and performing the calculation for Y values.

This value (MASSEST) was then used in a series of calculations to determine the difference (DIFF) between the mass inputted and the calculated mass. DIFF = MASS - MASSEST.

The error between the MASSEST value and the actual mass (ERROR) was determined for each piece of data by: ERROR = 100 * DIFF/MASS.

The mean and standard deviation data for ERROR were obtained by using the "MANDSD" routine from STATII***. Plots were then made for ERROR versus the sample mass to illustrate the effect of the mass on the error score.

DATA AND ADDITIONAL ANALYSIS SUMMARY DATA

APPENDIX D

TABLE 1

REGRESSION ANALYSIS SUMMARY TABLE FOR PHASE I TESTING

	MEAN	VARIANCE	STD DEV
DEP VARIABLE: NUMASC	144.31	9942.8	99.713
IND VARIABLE: NUDATA	69251.	0.26380E+10	51362.

NUMBER	CURVE	INDEX	A	B
1	Y=A+B*X	→0.98275	11.027	0.19246E-02
2	Y=A*EXP(B*X)	0.82725	45.733	0.13036E-04
3	Y=A*(X^B)	0.98386	0.73206E-02	0.88858
4	Y=A+(B/X)	0.40325	205.19	-0.21741E+07
5	Y=1/(A+B*X)	0.49305	0.21008E-01	-0.13384E-06
6	Y=X/(A*X+B)	0.94908	0.25687E-02	327.46

FOR WHICH CURVE ARE DETAILS DESIRED (NUMBER OR DONE) --?1

COEFFICIENTS:		EXPECTED VALUE	INTERVAL WIDTH	NON-SIMULTANEOUS 95.00% CONFIDENCE LIMITS	
CURVE 1:	A:	11.027	5.5867	8.2339	13.821
A+B*X	B:	0.19246E-02	0.64844E-04	0.18922E-02	0.19570E-02

13673.59 = F-STATISTIC FOR A LINEAR FIT. A 100.00% VALUE

APPENDIX D

TABLE 2

DATA FOR REGRESSION ANALYSIS FOR PHASE I TESTING

CASE NO.	[NUMASS]	[NUMASEST]	[DIFF]	[EPROR]
1	2.5000000E+01	2.7366935E+01	-2.3669350E+00	-9.4677401E+00
2	2.5000000E+01	2.5638662E+01	-6.3866234E-01	-2.5546494E+00
3	2.5000000E+01	2.2948100E+01	2.0519001E+00	8.2076006E+00
4	2.5000000E+01	2.7070550E+01	-2.0705497E+00	-8.2821989E+00
5	2.5000000E+01	2.7798041E+01	-2.7980409E+00	-1.1192163E+01
6	2.5000000E+01	2.5423110E+01	-4.2310953E-01	-1.6924381E+00
7	2.5000000E+01	2.9018224E+01	-4.0182245E+00	-1.6072898E+01
8	2.5000000E+01	3.0965899E+01	-5.9658992E+00	-2.3863597E+01
9	2.5000000E+01	2.6985868E+01	-1.9858682E+00	-7.9434729E+00
10	2.5000000E+01	3.0973598E+01	-5.9735975E+00	-2.3894390E+01
11	2.5000000E+01	3.1166056E+01	-6.1660557E+00	-2.4664223E+01
12	2.5000000E+01	3.1189151E+01	-6.1891506E+00	-2.4756602E+01
13	2.5000000E+01	3.1154508E+01	-6.1545081E+00	-2.4618032E+01
14	2.5000000E+01	2.6726050E+01	-1.7260499E+00	-6.9041996E+00
15	2.5000000E+01	2.5092082E+01	-9.2081785E-02	-3.6832714E-01
16	2.5000000E+01	2.7486259E+01	-2.4862590E+00	-9.9450359E+00
17	2.5000000E+01	2.5665606E+01	-6.6560650E-01	-2.6624260E+00
18	2.5000000E+01	2.6083240E+01	-1.0832403E+00	-4.3329611E+00
19	3.5200000E+01	4.1042935E+01	-5.8429356E+00	-1.6599249E+01
20	5.0000000E+01	5.2444210E+01	-2.4442096E+00	-4.8884192E+00
21	5.0000000E+01	5.0127016E+01	-1.2701559E-01	-2.5403118E-01
22	5.0000000E+01	6.0323440E+01	-1.0323440E+01	-2.0646879E+01
23	5.0000000E+01	5.0496535E+01	-4.9653482E-01	-9.9306965E-01
24	5.0000000E+01	5.4753706E+01	-4.7537055E+00	-9.5074110E+00
25	5.0000000E+01	5.2388397E+01	-2.3883967E+00	-4.7767935E+00
26	5.0000000E+01	4.9888368E+01	1.1163235E-01	2.2326469E-01
27	5.0000000E+01	5.1916875E+01	-1.9168749E+00	-3.8337498E+00
28	5.0000000E+01	5.0873753E+01	-8.7375259E-01	-1.7475052E+00
29	5.0000000E+01	5.7652122E+01	-7.6521225E+00	-1.5304245E+01
30	5.0000000E+01	5.1716719E+01	-1.7167187E+00	-3.4334373E+00
31	5.0000000E+01	5.7328793E+01	-7.3287930E+00	-1.4657586E+01
32	5.0000000E+01	5.5565878E+01	-5.5658779E+00	-1.1131756E+01
33	5.0000000E+01	5.4805669E+01	-4.8056693E+00	-9.6113386E+00
34	5.0000000E+01	5.9722970E+01	-9.7229705E+00	-1.9445941E+01
35	5.0000000E+01	5.5273342E+01	-5.2733421E+00	-1.0546684E+01
36	5.0000000E+01	5.9823049E+01	-9.8230486E+00	-1.9646097E+01
37	5.0000000E+01	5.2209411E+01	-2.2094111E+00	-4.4188223E+00
38	5.0000000E+01	5.5069336E+01	-5.0693364E+00	-1.0138673E+01
39	5.0000000E+01	5.6258727E+01	-6.2587271E+00	-1.2517454E+01
40	5.0000000E+01	5.6728324E+01	-6.7283244E+00	-1.3456649E+01
41	5.0000000E+01	5.8587469E+01	-8.5874686E+00	-1.7174937E+01
42	5.0000000E+01	5.9849993E+01	-9.8499929E+00	-1.9699986E+01
43	5.0000000E+01	5.8048586E+01	-8.0485859E+00	-1.6097172E+01
44	5.0000000E+01	4.9692060E+01	3.0793953E-01	6.1587906E-01
45	5.0000000E+01	5.1239423E+01	-1.2394228E+00	-2.4788456E+00
46	5.0000000E+01	5.0301019E+01	-3.0101871E-01	-6.0203743E-01
47	5.0000000E+01	5.3516984E+01	-3.5169840E+00	-7.0339680E+00
48	5.0000000E+01	4.9423937E+01	5.7606268E-01	1.1521254E+00
49	5.0000000E+01	5.1266367E+01	-1.2663670E+00	-2.5327339E+00
50	5.0000000E+01	5.1489618E+01	-1.4896183E+00	-2.9792366E+00

TABLE 2 - CONTINUED

51	5.0000000E+01	4.9521390E+01	4.7860956E-01	9.5721912E-01
52	5.0000000E+01	5.1258668E+01	-1.2586684E+00	-2.5173368E+00
53	5.0000000E+01	4.8614296E+01	1.3857040E+00	2.7714081E+00
54	5.0000000E+01	5.4264862E+01	-4.2648621E+00	-8.5297241E+00
55	5.0300000E+01	6.0046369E+01	-9.7463694E+00	-1.9376480E+01
56	5.0700000E+01	5.1080647E+01	-3.8064718E-01	-7.5078340E-01
57	5.2000000E+01	5.0690833E+01	1.3091674E+00	2.5176296E+00
58	5.2200000E+01	5.4296612E+01	-2.0966120E+00	-4.0164980E+00
59	5.2500000E+01	6.0923452E+01	-8.4234519E+00	-1.6044670E+01
60	5.8300000E+01	6.2092894E+01	-3.7928944E+00	-6.5058222E+00
61	5.8500000E+01	6.8037558E+01	-9.5375576E+00	-1.6303517E+01
62	6.4900000E+01	7.0863710E+01	-5.9637108E+00	-9.1890768E+00
63	6.5500000E+01	7.0084082E+01	-4.5840816E+00	-6.9985979E+00
64	7.1700000E+01	7.5638931E+01	-3.9389315E+00	-5.4936283E+00
65	7.5000000E+01	7.5639245E+01	-6.3924503E-01	-8.5232671E-01
66	7.6900000E+01	7.3007687E+01	3.8923130E+00	5.0615254E+00
67	8.0799998E+01	6.6673209E+01	1.4126789E+01	1.7483650E+01
68	8.6000000E+01	7.7880363E+01	8.1196375E+00	9.4414389E+00
69	8.6799998E+01	7.8367629E+01	8.4323692E+00	9.7147113E+00
70	8.7099998E+01	7.2422966E+01	1.4677032E+01	1.6850784E+01
71	8.8200000E+01	7.8367629E+01	9.8323708E+00	1.1147813E+01
72	8.8200000E+01	7.8367629E+01	9.8323708E+00	1.1147813E+01
73	8.9200000E+01	8.1875957E+01	7.3240423E+00	8.2108098E+00
74	8.9200000E+01	8.6748633E+01	2.4513664E+00	2.7481686E+00
75	8.9700000E+01	7.6516012E+01	1.3183988E+01	1.4697868E+01
76	8.9700000E+01	8.5091923E+01	4.6080770E+00	5.1372097E+00
77	9.2000000E+01	7.6905827E+01	1.5094173E+01	1.6406710E+01
78	9.6700000E+01	9.3570377E+01	3.1296225E+00	3.2364245E+00
79	9.9499999E+01	1.0312082E+02	-3.6208229E+00	-3.6390180E+00
80	9.9700000E+01	1.0253610E+02	-2.8361025E+00	-2.8446364E+00
81	9.9900000E+01	1.0243865E+02	-2.5386467E+00	-2.5411879E+00
82	1.0000000E+02	1.1517396E+02	-1.5173964E+01	-1.5173964E+01
83	1.0000000E+02	9.8083694E+01	1.9163055E+00	1.9163055E+00
84	1.0000000E+02	1.0140167E+02	-1.4016705E+00	-1.4016705E+00
85	1.0000000E+02	9.6247645E+01	3.7523546E+00	3.7523546E+00
86	1.0000000E+02	9.9667624E+01	3.3237648E-01	3.3237648E-01
87	1.0000000E+02	9.7868142E+01	2.1318579E+00	2.1318579E+00
88	1.0000000E+02	1.0676740E+02	-6.7673988E+00	-6.7673988E+00
89	1.0000000E+02	1.1174436E+02	-1.1744362E+01	-1.1744362E+01
90	1.0000000E+02	1.0194825E+02	-1.9482508E+00	-1.9482508E+00
91	1.0000000E+02	1.1413854E+02	-1.4138539E+01	-1.4138539E+01
92	1.0000000E+02	1.0222924E+02	-2.2292395E+00	-2.2292395E+00
93	1.0000000E+02	1.0103600E+02	-1.0360003E+00	-1.0360003E+00
94	1.0000000E+02	1.0214629E+02	-2.1462879E+00	-2.1462879E+00
95	1.0000000E+02	1.0720235E+02	-7.2023535E+00	-7.2023535E+00
96	1.0000000E+02	1.0913770E+02	-8.1377001E+00	-8.1377001E+00
97	1.0000000E+02	9.2152140E+01	7.8478603E+00	7.8478603E+00
98	1.0000000E+02	1.0291054E+02	-2.9105406E+00	-2.9105406E+00
99	1.0000000E+02	1.0427314E+02	-4.2731438E+00	-4.2731438E+00
100	1.0000000E+02	1.1153651E+02	-1.1536508E+01	-1.1536508E+01
101	1.0000000E+02	1.0681744E+02	-6.8174381E+00	-6.8174381E+00
102	1.0000000E+02	9.3083110E+01	6.9168901E+00	6.9168901E+00
103	1.0000000E+02	1.0378430E+02	-3.7842999E+00	-3.7842999E+00
104	1.0000000E+02	1.0904225E+02	-9.0422525E+00	-9.0422525E+00
105	1.0000000E+02	1.0971201E+02	-9.7120056E+00	-9.7120056E+00
106	1.0000000E+02	1.0237166E+02	-2.3716583E+00	-2.3716583E+00
107	1.0000000E+02	1.1031248E+02	-1.0312475E+01	-1.0312475E+01
108	1.0000000E+02	8.1291235E+01	1.8708765E+01	1.8708765E+01
109	1.0030000E+02	1.0828586E+02	-7.9858580E+00	-7.9619721E+00
110	1.0150000E+02	9.4252553E+01	7.2474470E+00	7.1403419E+00
111	1.0160000E+02	1.0565461E+02	-4.0546141E+00	-3.9907619E+00
112	1.0180000E+02	9.6299077E+01	5.5009222E+00	5.4036564E+00
113	1.0200000E+02	9.5519448E+01	6.4805517E+00	6.3534821E+00
114	1.0230000E+02	1.0604443E+02	-3.7444286E+00	-3.6602431E+00
115	1.0290000E+02	1.0857822E+02	-5.6782198E+00	-5.5181922E+00

APPENDIX D

TABLE 2 - CONTINUED

116	1.0340000E+02	1.0594698E+02	-2.5469761E+00	-2.4632264E+00
117	1.0470000E+02	9.7955787E+01	6.7442131E+00	6.4414643E+00
118	1.0650000E+02	1.1588723E+02	-9.3872337E+00	-8.8143040E+00
119	1.1040000E+02	1.1501015E+02	-4.6101503E+00	-4.1758608E+00
120	1.1040000E+02	1.0623934E+02	4.1606636E+00	3.7687171E+00
121	1.1140000E+02	1.1452288E+02	-3.1228838E+00	-2.8033068E+00
122	1.2080000E+02	1.0097684E+02	1.9823155E+01	1.6409897E+01
123	1.2090000E+02	1.1715413E+02	3.7458715E+00	3.0983222E+00
124	1.2090000E+02	1.2270898E+02	-1.8089781E+00	-1.4962598E+00
125	1.2100000E+02	1.0906549E+02	1.1934513E+01	9.8632339E+00
126	1.2280000E+02	1.1081965E+02	1.1980350E+01	9.7559850E+00
127	1.2320000E+02	1.0731132E+02	1.5888677E+01	1.2896653E+01
128	1.2760000E+02	1.0594698E+02	2.1653024E+01	1.6969454E+01
129	1.2830000E+02	1.1247636E+02	1.5823639E+01	1.2333312E+01
130	1.3200000E+02	1.3781427E+02	-5.8142719E+00	-4.4047515E+00
131	1.3620000E+02	1.2650967E+02	9.6903324E+00	7.1147816E+00
132	1.3870000E+02	1.4639018E+02	-7.6901836E+00	-5.5444728E+00
133	1.4230000E+02	1.2426824E+02	1.8031764E+01	1.2671654E+01
134	1.4450000E+02	1.5321193E+02	-8.7119293E+00	-6.0290169E+00
135	1.4520000E+02	1.3342887E+02	1.1771133E+01	8.1068412E+00
136	1.4630000E+02	1.2290389E+02	2.3396113E+01	1.5991875E+01
137	1.4760000E+02	1.3830154E+02	9.2984600E+00	6.2997697E+00
138	1.4800000E+02	1.2611985E+02	2.1880149E+01	1.4783884E+01
139	1.4970000E+02	1.5886423E+02	-9.1642323E+00	-6.1217317E+00
140	1.5000000E+02	1.6339623E+02	-1.3396235E+01	-8.9308230E+00
141	1.5000000E+02	1.5516288E+02	-5.1628819E+00	-3.4419212E+00
142	1.5000000E+02	1.5089801E+02	-8.9801407E-01	-5.9867605E-01
143	1.5000000E+02	1.3664483E+02	1.3355169E+01	8.9034462E+00
144	1.5000000E+02	1.7314616E+02	-2.3146156E+01	-1.5430771E+01
145	1.5000000E+02	1.5351159E+02	-3.5115929E+00	-2.3410619E+00
146	1.5000000E+02	1.5300350E+02	-3.0035038E+00	-2.0023359E+00
147	1.5000000E+02	1.7250335E+02	-2.2503345E+01	-1.5002230E+01
148	1.5000000E+02	1.5594041E+02	-5.9404125E+00	-3.9602750E+00
149	1.5000000E+02	1.6860958E+02	-1.8609581E+01	-1.2406387E+01
150	1.5000000E+02	1.5336532E+02	-3.3653240E+00	-2.2435493E+00
151	1.5000000E+02	1.5830765E+02	-8.3076458E+00	-5.5384305E+00
152	1.5000000E+02	1.5292652E+02	-2.9265213E+00	-1.9510142E+00
153	1.5000000E+02	1.6188736E+02	-1.1887363E+01	-7.9249089E+00
154	1.5000000E+02	1.5755706E+02	-7.5570602E+00	-5.0380402E+00
155	1.5000000E+02	1.6500133E+02	-1.5001333E+01	-1.0000889E+01
156	1.5000000E+02	1.5668330E+02	-6.6833000E+00	-4.4555333E+00
157	1.5000000E+02	1.6363873E+02	-1.3638731E+01	-9.0924873E+00
158	1.5000000E+02	1.6142931E+02	-1.1429314E+01	-7.6195424E+00
159	1.5050000E+02	1.6139802E+02	-1.0898022E+01	-7.2412104E+00
160	1.5230000E+02	1.4580546E+02	6.4945393E+00	4.2643068E+00
161	1.5340000E+02	1.5623299E+02	-2.8329887E+00	-1.8467984E+00
162	1.5450000E+02	1.5447882E+02	2.1177292E-02	1.3706985E-02
163	1.5520000E+02	1.4775453E+02	7.4454689E+00	4.7973382E+00
164	1.5530000E+02	1.4200477E+02	1.3295225E+01	8.5609950E+00
165	1.5650000E+02	1.3089507E+02	2.5604927E+01	1.6360976E+01
166	1.5940000E+02	1.4541565E+02	1.3984352E+01	8.7731193E+00
167	1.6470000E+02	1.8965954E+02	-2.4959543E+01	-1.5154550E+01
168	1.6480000E+02	1.7630841E+02	-1.1508411E+01	-6.9832594E+00
169	1.6520000E+02	1.6071585E+02	4.4841518E+00	2.7143776E+00
170	1.6540000E+02	1.4366148E+02	2.1738518E+01	1.3142998E+01
171	1.6590000E+02	1.7669823E+02	-1.0798227E+01	-6.5088772E+00
172	1.6610000E+02	1.4619527E+02	1.9904726E+01	1.1983580E+01
173	1.6910000E+02	1.7504151E+02	-5.9415150E+00	-3.5136103E+00
174	1.7090000E+02	1.7192300E+02	-1.0230007E+00	-5.9859609E-01
175	1.7410000E+02	1.7211791E+02	1.9820900E+00	1.1384779E+00
176	1.7740000E+02	1.8478687E+02	-7.3868656E+00	-4.1639603E+00
177	1.8200000E+02	1.8478687E+02	-2.7868652E+00	-1.5312446E+00
178	1.8210000E+02	1.6519871E+02	1.6901287E+01	9.2813219E+00
179	1.8240000E+02	1.5847442E+02	2.3925583E+01	1.3117096E+01
180	1.8570000E+02	1.7377462E+02	1.1925377E+01	6.4218508E+00

APPENDIX D

TABLE 2 - CONTINUED

181	1.8760000E+02	1.7153319E+02	1.6066813E+01	8.5643991E+00
182	1.8820000E+02	1.7192300E+02	1.6276999E+01	8.6487771E+00
183	1.9020000E+02	1.9560420E+02	-5.4042053E+00	-2.8413277E+00
184	1.9950000E+02	2.0057434E+02	-1.0743370E+00	-5.3851479E-01
185	2.0000000E+02	1.9836970E+02	1.6303024E+00	8.1515121E-01
186	2.0000000E+02	2.2074721E+02	-2.0747211E+01	-1.0373606E+01
187	2.0000000E+02	1.7786767E+02	2.2132334E+01	1.1066167E+01
188	2.0000000E+02	1.8751556E+02	1.2484436E+01	6.2422180E+00
189	2.0000000E+02	2.0622664E+02	-6.2266407E+00	-3.1133204E+00
190	2.0000000E+02	1.9784564E+02	2.1543636E+00	1.0771818E+00
191	2.0000000E+02	2.0115906E+02	-1.1590576E+00	-5.7952881E-01
192	2.0000000E+02	2.0147212E+02	-1.4721203E+00	-7.3606014E-01
193	2.0000000E+02	2.1049455E+02	-1.0494551E+01	-5.2472754E+00
194	2.0000000E+02	2.0643754E+02	-6.4375362E+00	-3.2187681E+00
195	2.0000000E+02	2.1575635E+02	-1.5756351E+01	-7.8781757E+00
196	2.0000000E+02	1.9930744E+02	6.9256210E-01	3.4628105E-01
197	2.0000000E+02	1.7504151E+02	2.4958487E+01	1.2479243E+01
198	2.0000000E+02	2.1918795E+02	-1.9187954E+01	-9.5939770E+00
199	2.0000000E+02	1.6831722E+02	3.1682779E+01	1.5841390E+01
200	2.0110000E+02	2.0846807E+02	-7.3680668E+00	-3.6638821E+00
201	2.0190000E+02	2.1314583E+02	-1.1245832E+01	-5.5700012E+00
202	2.0340000E+02	2.0340049E+02	-4.8828125E-04	-2.4005961E-04
203	2.2500000E+02	2.0690881E+02	1.8091192E+01	8.0405298E+00
204	2.5000000E+02	2.4686476E+02	3.1352425E+00	1.2540970E+00
205	2.5000000E+02	2.3682704E+02	1.3172964E+01	5.2691857E+00
206	2.5000000E+02	2.5466104E+02	-4.6610394E+00	-1.8644157E+00
207	2.5000000E+02	2.7415174E+02	-2.4151737E+01	-9.6606948E+00
208	2.5000000E+02	2.7268995E+02	-2.2689945E+01	-9.0759780E+00
209	2.5500000E+02	2.5183489E+02	3.1651096E+00	1.2412195E+00
210	2.7500000E+02	2.6109296E+02	1.3907036E+01	5.0571039E+00
211	2.7500000E+02	2.6898671E+02	6.0132942E+00	2.1866525E+00
212	2.9980000E+02	2.8799014E+02	1.1809860E+01	3.9392462E+00
213	3.0000000E+02	3.2102688E+02	-2.1026882E+01	-7.0089607E+00
214	3.0000000E+02	3.0728594E+02	-7.2859383E+00	-2.4286461E+00
215	3.0000000E+02	2.8545636E+02	1.4543644E+01	4.8478813E+00
216	3.0000000E+02	2.8243528E+02	1.7564716E+01	5.8549054E+00
217	3.0000000E+02	3.1946763E+02	-1.9467628E+01	-6.4892095E+00
218	3.0000000E+02	2.9637115E+02	3.6288528E+00	1.2096176E+00
219	3.0000000E+02	2.6771981E+02	3.2280190E+01	1.0760063E+01
220	3.0000000E+02	3.0543432E+02	-5.4343185E+00	-1.8114395E+00
221	3.1590000E+02	3.3018752E+02	-1.4287518E+01	-4.5227976E+00
222	3.2370000E+02	2.9812531E+02	2.5574692E+01	7.9007390E+00
223	3.2500000E+02	2.9325264E+02	3.1747364E+01	9.7684197E+00
224	3.4000000E+02	3.3350093E+02	6.4990692E+00	1.9114909E+00
225	3.4030000E+02	3.3223404E+02	8.0659637E+00	2.3702509E+00
226	3.5000000E+02	3.4295393E+02	7.0460739E+00	2.0131640E+00
227	3.5000000E+02	3.6916891E+02	-1.9168915E+01	-5.4768328E+00
228	3.5000000E+02	2.8467673E+02	6.5323273E+01	1.8663792E+01
229	3.5000000E+02	3.8466402E+02	-3.4664017E+01	-9.9040048E+00
230	3.7500000E+02	3.7209253E+02	2.9074745E+00	7.7532654E-01
231	3.7500000E+02	3.6312679E+02	1.1873207E+01	3.1661886E+00
232	3.9880000E+02	4.1701859E+02	-1.8218590E+01	-4.5683525E+00
233	4.0000000E+02	3.8573601E+02	1.4263992E+01	3.5659981E+00
234	4.0000000E+02	4.4469540E+02	-4.4695396E+01	-1.1173849E+01
235	4.0000000E+02	3.9723552E+02	2.7644768E+00	6.9111919E-01
236	4.0000000E+02	3.5679231E+02	4.3207691E+01	1.0801923E+01
237	4.0000000E+02	3.7433395E+02	2.5666050E+01	6.4165125E+00
238	4.0000000E+02	3.8495638E+02	1.5043621E+01	3.7609053E+00
239	4.0000000E+02	3.6780456E+02	3.2195438E+01	8.0488596E+00
240	4.0210000E+02	4.1224336E+02	-1.0143360E+01	-2.5225964E+00
241	4.2000000E+02	4.3036972E+02	-1.0369724E+01	-2.4689820E+00
242	4.5000000E+02	5.0121843E+02	-5.1218433E+01	-1.1381874E+01

APPENDIX D

TABLE 3

REGRESSION ANALYSIS SUMMARY TABLE FOR PHASE II TESTING

	MEAN	VARIANCE	STD DEV
DEP VARIABLE: MASSS	160.93	13764.	117.32
IND VARIABLE: DATAS	79697.	0.34521E+10	58755.

NUMBER	CURVE	INDEX	A	B
1	Y=A+B*X	→ 0.98676	2.8511	0.19835E-02
2	Y=A*EXP(B*X)	0.85520	42.815	0.12911E-04
3	Y=A*(X^B)	0.97078	0.51013E-02	0.91787
4	Y=A+(B/X)	0.38693	225.40	-0.24316E+07
5	Y=1/(A+B*X)	0.51664	0.22307E-01	-0.13207E-06
6	Y=X/(A*X+B)	0.87063	0.28823E-02	335.65

FOR WHICH CURVE ARE DETAILS DESIRED (NUMBER OR DONE) --?1

COEFFICIENTS:		EXPECTED VALUE	INTERVAL WIDTH	NON-SIMULTANEOUS 95.00% CONFIDENCE LIMITS	
CURVE 1	A:	2.8511	9.6202	-1.9590	7.6612
A+B*X	B:	0.19835E-02	0.97350E-04	0.19348E-02	0.20322E-02

6558.10 = F-STATISTIC FOR A LINEAR FIT, A 100.00% VALUE

APPENDIX D

TABLE 4

DATA REGRESSION ANALYSIS FOR PHASE II TESTING

CASE NO.	[MASSS]	[MASSSEST]	[ERROR]
1	2.4450000E+01	1.5583281E+01	3.6264698E+01
2	2.5100000E+01	3.0560812E+01	-2.1756223E+01
3	2.5350000E+01	2.5548467E+01	-7.8290642E-01
4	2.5700000E+01	2.1414819E+01	1.6673856E+01
5	2.5800000E+01	2.0274297E+01	2.1417453E+01
6	2.6100000E+01	2.6121703E+01	-8.3152362E-02
7	2.6100000E+01	2.7117428E+01	-3.8981913E+00
8	2.6300000E+01	4.2864563E+01	-6.2983130E+01
9	2.6500000E+01	1.6456028E+01	3.7901779E+01
10	2.7000000E+01	2.4173890E+01	1.0467075E+01
11	4.8800000E+01	4.4790557E+01	8.2160714E+00
12	5.0100000E+01	5.5275424E+01	-1.0330187E+01
13	5.0800000E+01	3.9387459E+01	2.2465632E+01
14	5.1500000E+01	5.1518644E+01	-3.6201662E-02
15	5.1700000E+01	5.6156105E+01	-8.6191581E+00
16	5.2400000E+01	5.9333698E+01	-1.3232249E+01
17	5.3550000E+01	7.1322069E+01	-3.3187805E+01
18	5.3700000E+01	4.5708925E+01	1.4880958E+01
19	5.6000000E+01	4.7416732E+01	1.5327264E+01
20	5.6150000E+01	4.2259591E+01	2.4738039E+01
21	7.3450000E+01	7.7673288E+01	-5.7498823E+00
22	7.4099999E+01	6.7987779E+01	8.2486111E+00
23	7.4099999E+01	8.2556705E+01	-1.1412559E+01
24	7.4700000E+01	6.2650137E+01	1.6131008E+01
25	7.5950000E+01	9.5152033E+01	-2.5282466E+01
26	7.6200000E+01	7.5578695E+01	8.1536026E-01
27	7.6299999E+01	9.0232913E+01	-1.8260700E+01
28	7.6599999E+01	6.7888603E+01	1.1372580E+01
29	7.8000000E+01	8.4575925E+01	-8.4306729E+00
30	7.8299999E+01	7.5304970E+01	3.8250696E+00
31	8.9700000E+01	1.0106688E+02	-1.2672105E+01
32	9.8000000E+01	1.0889383E+02	-1.1116156E+01
33	9.8500000E+01	9.6524626E+01	2.0054561E+00
34	9.9099999E+01	9.2414781E+01	6.7459322E+00
35	9.9450000E+01	1.0826903E+02	-8.8677989E+00
36	1.0040000E+02	9.1907001E+01	8.4591625E+00
37	1.0060000E+02	1.0257038E+02	-1.9586319E+00
38	1.0110000E+02	1.2251662E+02	-2.1183604E+01
39	1.0125000E+02	1.0870342E+02	-7.3613984E+00
40	1.0240000E+02	9.1204836E+01	1.0932777E+01

APPENDIX D

TABLE 4 - CONTINUED

41	1.2320000E+02	1.1883720E+02	3.5412343E+00
42	1.2330000E+02	1.4085026E+02	-1.4233790E+01
43	1.2420000E+02	1.0624386E+02	1.4457443E+01
44	1.2450000E+02	1.3123616E+02	-5.4105690E+00
45	1.2520000E+02	1.3861286E+02	-1.0713144E+01
46	1.2520000E+02	1.1950168E+02	4.5513756E+00
47	1.2525000E+02	1.2296886E+02	1.8212667E+00
48	1.2585000E+02	1.3087913E+02	-3.9961273E+00
49	1.4795000E+02	1.6197273E+02	-9.4780183E+00
50	1.5010000E+02	1.4669965E+02	2.2653876E+00
51	1.5020000E+02	1.5925134E+02	-6.0261931E+00
52	1.5050000E+02	1.6331358E+02	-8.5140089E+00
53	1.5110000E+02	1.6713582E+02	-1.0612720E+01
54	1.5115000E+02	1.1826991E+02	2.1753282E+01
55	1.5170000E+02	1.5912043E+02	-4.8915169E+00
56	1.5300000E+02	1.6713780E+02	-9.2403935E+00
57	1.5330000E+02	1.4850663E+02	3.1267877E+00
58	1.5340000E+02	1.4901640E+02	2.8576285E+00
59	1.5440000E+02	1.4510887E+02	6.0175701E+00
60	1.9360000E+02	1.9017833E+02	1.7673930E+00
61	1.9490000E+02	1.9547035E+02	-2.9263562E-01
62	1.9560000E+02	1.9155687E+02	2.0670394E+00
63	1.9675000E+02	2.2115886E+02	-1.2406031E+01
64	1.9775000E+02	1.8347999E+02	7.2161862E+00
65	1.9880000E+02	1.7936816E+02	9.7745659E+00
66	1.9985000E+02	2.1207238E+02	-6.1157767E+00
67	2.0070000E+02	1.8494581E+02	7.8496206E+00
68	2.0165000E+02	2.1403407E+02	-6.1413713E+00
69	2.0280000E+02	2.0903363E+02	-3.0737826E+00
70	2.9300000E+02	2.7060594E+02	7.6430233E+00
71	2.9550000E+02	3.0657701E+02	-3.7485642E+00
72	2.9710000E+02	3.1161316E+02	-4.8849401E+00
73	2.9900000E+02	2.9215089E+02	2.2906708E+00
74	3.0000000E+02	3.1154175E+02	-3.8472494E+00
75	3.0060000E+02	3.1454876E+02	-4.6403064E+00
76	3.0080000E+02	3.0473432E+02	-1.3079516E+00
77	3.0110000E+02	3.0312965E+02	-6.7408019E-01
78	3.0300000E+02	2.8038864E+02	7.4624946E+00
79	3.0330000E+02	2.7934928E+02	7.8967088E+00
80	3.0360000E+02	2.9981917E+02	1.2453328E+00
81	3.9750000E+02	4.0919818E+02	-2.9429387E+00
82	3.9785000E+02	3.9432578E+02	8.8581614E-01
83	3.9890000E+02	4.3087405E+02	-8.0155550E+00
84	3.9920000E+02	4.1651339E+02	-4.3370222E+00
85	3.9945000E+02	3.6419418E+02	8.8260894E+00
86	4.0090000E+02	3.8598311E+02	3.7208504E+00
87	4.0250000E+02	4.2080175E+02	-4.5470196E+00
88	4.0320000E+02	3.6246852E+02	1.0102052E+01
89	4.0330000E+02	3.7988181E+02	5.8066418E+00
90	4.0685000E+02	4.0223207E+02	1.1350433E+00

APPENDIX D

TABLE 5

REGRESSION ANALYSIS TABLE FOR PHASE III TESTING FOR 25 THROUGH 400 GRAM SAMPLES

	MEAN	VARIANCE	STD DEV
DEP VARIABLE: MASS	159.54	13467.	116.05
IND VARIABLE: DATA	17811.	0.19740E+09	14050.

NUMBER	CURVE	INDEX	A	B
1	Y=A+B*X	→ 0.98929	13.220	0.82153E-02
2	Y=A*EXP(B*X)	0.83620	46.414	0.52979E-04
3	Y=A*(X^B)	0.98927	0.34346E-01	0.86496
4	Y=A+(B/X)	0.40049	222.65	-0.48633E+06
5	Y=1/(A+B*X)	0.48469	0.21376E-01	-0.53793E-06
6	Y=X/(A*X+B)	0.96001	0.26543E-02	70.437

FOR WHICH CURVE ARE DETAILS DESIRED (NUMBER OR DONE) --?1

COEFFICIENTS:		EXPECTED VALUE	INTERVAL WIDTH	NON-SIMULTANEOUS 95.00% CONFIDENCE LIMITS	
CURVE 1	A:	13.220	8.1967	9.1214	17.318
A+B*X	B:	0.82153E-02	0.36209E-03	0.80343E-02	0.83964E-02

8131.94 = F-STATISTIC FOR A LINEAR FIT, A 100.00% VALUE

APPENDIX D

TABLE 6

REGRESSION ANALYSIS TABLE FOR PHASE III TESTING
FOR 75 THROUGH 400 GRAM SAMPLES

		MEAN	VARIANCE	STD DEV
DEP VARIABLE:	MASS1	193.82	11950.	109.31
IND. VARIABLE:	DATA1	21897.	0.17767E+09	13329.

NUMBER	CURVE	INDEX	A	B
1	Y=A+B*X	→ 0.98503	15.589	0.81395E-02
2	Y=A*EXP(B*X)	0.92829	69.550	0.39891E-04
3	Y=A*(X^B)	0.98699	0.19255E-01	0.92328
4	Y=A+(B/X)	0.78129	372.09	-0.27880E+07
5	Y=1/(A+B*X)	0.77774	0.11985E-01	-0.23188E-06
6	Y=X/(A*X+B)	0.97656	0.51731E-03	99.932

FOR WHICH CURVE ARE DETAILS DESIRED (NUMBER OR DONE) --?1

COEFFICIENTS:		EXPECTED VALUE	INTERVAL WIDTH	NON-SIMULTANEOUS 95.00% CONFIDENCE LIMITS	
CURVE 1	A:	15.589	12.426	9.3757	21.802
A+B*X	B:	0.81395E-02	0.48568E-03	0.78967E-02	0.83824E-02

4473.51 = F-STATISTIC FOR A LINEAR FIT, A 100.00% VALUE

APPENDIX D

TABLE 7

DATA FOR REGRESSION ANALYSIS FOR PHASE III TESTING

CASE NO.	[MASS]	[MASSEST1]	[DIFF1]	[ERROR1]
1	2.4200000E+01	2.6323155E+01	-2.1231556E+00	-8.7733703E+00
2	2.8600000E+01	2.9436757E+01	-8.3675671E-01	-2.9257227E+00
3	2.5100000E+01	3.0940158E+01	-5.8401580E+00	-2.3267562E+01
4	2.4700000E+01	2.9535340E+01	-4.8353405E+00	-1.9576277E+01
5	2.6600000E+01	2.8245537E+01	-1.6455374E+00	-6.1862308E+00
6	2.5300000E+01	2.6388878E+01	-1.0888779E+00	-4.3038653E+00
7	2.4900000E+01	2.8664518E+01	-3.7645180E+00	-1.5118546E+01
8	2.7300000E+01	3.4423448E+01	-7.1234481E+00	-2.6093217E+01
9	2.5000000E+01	3.2985769E+01	-7.9857693E+00	-3.1943077E+01
10	2.4800000E+01	2.6857150E+01	-2.0571504E+00	-8.2949612E+00
11	5.4900000E+01	6.1509315E+01	-6.6093149E+00	-1.2038825E+01
12	5.0400000E+01	4.9818933E+01	5.8106661E-01	1.1529099E+00
13	5.0000000E+01	5.4509873E+01	-4.5098729E+00	-9.0197458E+00
14	5.4100000E+01	5.9414411E+01	-5.3144112E+00	-9.8233109E+00
15	5.1500000E+01	5.6703360E+01	-5.2033601E+00	-1.0103612E+01
16	5.5100000E+01	5.4830270E+01	2.6973009E-01	4.8952830E-01
17	5.5000000E+01	5.3359730E+01	1.6402698E+00	2.9823087E+00
18	5.6300000E+01	4.9005618E+01	7.2943821E+00	1.2956274E+01
19	5.4000000E+01	5.5924322E+01	-1.9243222E+00	-3.3783745E+00
20	5.3600000E+01	5.2291740E+01	1.3082595E+00	2.4407826E+00
21	7.8599999E+01	7.9886955E+01	-1.2869558E+00	-1.6373484E+00
22	7.8200000E+01	7.8556076E+01	-3.5607624E-01	-4.5534046E-01
23	7.6500000E+01	7.3331141E+01	3.1688595E+00	4.1423000E+00
24	7.9400000E+01	7.8350694E+01	1.0493059E+00	1.3215440E+00
25	7.6000000E+01	8.1349280E+01	-5.3492804E+00	-7.0385268E+00
26	7.6500000E+01	7.9410468E+01	-2.9104681E+00	-3.8045335E+00
27	7.6799999E+01	8.4939369E+01	-8.1393700E+00	-1.0598138E+01
28	7.5799999E+01	8.5005092E+01	-9.2050924E+00	-1.2143921E+01
29	7.3500000E+01	8.4290360E+01	-1.0790360E+01	-1.4680763E+01
30	7.2799999E+01	7.1236238E+01	1.5637617E+00	2.1480244E+00
31	9.9599999E+01	8.9950706E+01	9.6492929E+00	9.6880451E+00
32	1.0100000E+02	9.5118134E+01	5.8818655E+00	5.8236292E+00
33	1.0040000E+02	9.2168839E+01	8.2311602E+00	8.1983668E+00
34	1.0350000E+02	9.5142780E+01	8.3572197E+00	8.0746094E+00
35	1.0080000E+02	1.0185469E+02	-1.0546865E+00	-1.0463160E+00
36	1.0120000E+02	1.0259406E+02	-1.3940639E+00	-1.3775336E+00
37	1.0090000E+02	1.1396405E+02	-1.3064049E+01	-1.2947521E+01
38	1.0290000E+02	1.1287963E+02	-9.9796286E+00	-9.6983757E+00
39	9.9900000E+01	1.0862410E+02	-8.7240992E+00	-8.7328321E+00
40	9.9599999E+01	9.6917287E+01	2.6827126E+00	2.6934865E+00

APPENDIX D

TABLE 7 - CONTINUED

41	1.2670000E+02	1.2505471E+02	1.6452875E+00	1.2985695E+00
42	1.2780000E+02	1.2625415E+02	1.5458517E+00	1.2095866E+00
43	1.2200000E+02	1.2262298E+02	-6.2298203E-01	-5.1064100E-01
44	1.2200000E+02	1.1801419E+02	3.9858055E+00	3.2670537E+00
45	1.2590000E+02	1.2236009E+02	3.5399075E+00	2.9116819E+00
46	1.2500000E+02	1.2547369E+02	-4.7369289E-01	-3.7895431E-01
47	1.2620000E+02	1.3577569E+02	-9.5756884E+00	-7.5877087E+00
48	1.2700000E+02	1.1536887E+02	1.1631134E+01	9.1583732E+00
49	1.2470000E+02	1.3417370E+02	-9.4737024E+00	-7.5971952E+00
50	1.2570000E+02	1.2997568E+02	-4.2756815E+00	-3.4014968E+00
51	1.5100000E+02	1.4685814E+02	4.1418629E+00	2.7429555E+00
52	1.4920000E+02	1.4930630E+02	-1.0629845E-01	-7.1245608E-02
53	1.5340000E+02	1.5007032E+02	3.3296776E+00	2.1705851E+00
54	1.4890000E+02	1.5730801E+02	-8.4080067E+00	-5.6467473E+00
55	1.5040000E+02	1.5215701E+02	-1.7570095E+00	-1.1682244E+00
56	1.5320000E+02	1.3278532E+02	2.0414682E+01	1.3325511E+01
57	1.5280000E+02	1.4481252E+02	7.9874744E+00	5.2274048E+00
58	1.5820000E+02	1.5890999E+02	-7.0999336E-01	-4.4879480E-01
59	1.5330000E+02	1.5934540E+02	-6.0454044E+00	-3.9435124E+00
60	1.5400000E+02	1.3481450E+02	1.9185503E+01	1.2458119E+01
61	2.0110000E+02	1.7861851E+02	2.2481485E+01	1.1179257E+01
62	2.0290000E+02	1.9659360E+02	6.3063965E+00	3.1081304E+00
63	1.9940000E+02	2.0633696E+02	-6.9369583E+00	-3.4789159E+00
64	2.0040000E+02	1.9954290E+02	8.5709953E-01	4.2769438E-01
65	1.9630000E+02	2.0475140E+02	-8.4514046E+00	-4.3053513E+00
66	2.0090000E+02	2.0417633E+02	-3.2763329E+00	-1.6308277E+00
67	1.9920000E+02	2.0109559E+02	-1.8955936E+00	-9.5160324E-01
68	2.0160000E+02	2.0763499E+02	-6.0349770E+00	-2.9935402E+00
69	1.9760000E+02	2.1236699E+02	-1.4766994E+01	-7.4731754E+00
70	1.9810000E+02	1.7978509E+02	1.8314913E+01	9.2452867E+00
71	3.0870000E+02	2.9321383E+02	1.5486168E+01	5.0165753E+00
72	2.9770000E+02	2.8015149E+02	1.7548508E+01	5.8946953E+00
73	3.0640000E+02	2.9446255E+02	1.1937443E+01	3.8960323E+00
74	3.0970000E+02	3.0865860E+02	1.0413933E+00	3.3625873E-01
75	2.9990000E+02	2.9950675E+02	3.9324570E-01	1.3112561E-01
76	3.1010000E+02	3.0345831E+02	6.6416855E+00	2.1417883E+00
77	3.1240000E+02	3.1424501E+02	-1.8450165E+00	-5.9059427E-01
78	3.0050000E+02	3.0732772E+02	-6.8277245E+00	-2.2721213E+00
79	3.0330000E+02	3.2093227E+02	-1.7632275E+01	-5.8134766E+00
80	3.0260000E+02	2.7214978E+02	3.0450218E+01	1.0062861E+01
81	3.9610000E+02	3.8991620E+02	6.1837959E+00	1.5611704E+00
82	3.9500000E+02	3.5759719E+02	3.7402813E+01	9.4690666E+00
83	3.9430000E+02	3.9569156E+02	-1.3915634E+00	-3.5291996E-01
84	3.9500000E+02	4.0376721E+02	-8.7672119E+00	-2.2195473E+00
85	3.9400000E+02	3.9666919E+02	-2.6691856E+00	-6.7745829E-01
86	3.9650000E+02	4.0056324E+02	-4.0632401E+00	-1.0247768E+00
87	4.0010000E+02	3.8280175E+02	1.7298252E+01	4.3234822E+00
88	3.9580000E+02	3.7097992E+02	2.4820080E+01	6.2708640E+00
89	4.0020000E+02	4.6113470E+02	-6.0934700E+01	-1.5226062E+01
90	4.0020000E+02	4.2649075E+02	-2.6290752E+01	-6.5694035E+00

APPENDIX D

TABLE 8

STANDARD DEVIATION AND CALCULATION ERROR VALUES

FOR WEIGHT GROUPED DATA FOR PHASE III TESTING.

	MAXIMUM LIKELIHOOD ESTIMATES FOR POPULATION PARAMETERS	UNBIASED ESTIMATES FOR POPULATION PARAMETERS
ARITHMETIC MEAN:	-0.12894E-02	-0.12894E-02
STANDARD DEVIATION:	14.944	15.752
VARIANCE:	223.32	248.13
NUMBER OF VALUES:	10	

INDEX	ERROR25 VARIABLE
1	14.024
2	9.3648
3	-12.101
4	-4.8850
5	10.306
6	17.350
7	1.5106
8	-23.327
9	-25.541
10	12.685

	MAXIMUM LIKELIHOOD ESTIMATES FOR POPULATION PARAMETERS	UNBIASED ESTIMATES FOR POPULATION PARAMETERS
ARITHMETIC MEAN:	0.14904E-04	0.14904E-04
STANDARD DEVIATION:	9.1997	9.6973
VARIANCE:	84.634	94.038
NUMBER OF VALUES:	10	

INDEX	ERROR50 VARIABLE
1	-13.228
2	6.5213
3	-6.3036
4	-9.9173
5	-8.6901
6	2.7873
7	6.0523
8	18.177
9	-1.5627
10	6.1634

APPENDIX D

TABLE 8 -- CONTINUED

	MAXIMUM LIKELIHOOD ESTIMATES FOR POPULATION PARAMETERS	UNBIASED ESTIMATES FOR POPULATION PARAMETERS
ARITHMETIC MEAN:	-0.77553E-05	-0.77553E-05
STANDARD DEVIATION:	6.9665	7.3433
VARIANCE:	48.532	53.924
NUMBER OF VALUES:	10	

INDEX	ERROR75 VARIABLE
1	2.4649
2	3.9231
3	9.6420
4	5.6726
5	-3.0844
6	0.50372
7	-7.3861
8	-8.9025
9	-11.192
10	8.3587

	MAXIMUM LIKELIHOOD ESTIMATES FOR POPULATION PARAMETERS	UNBIASED ESTIMATES FOR POPULATION PARAMETERS
ARITHMETIC MEAN:	0.48034E-04	0.48034E-04
STANDARD DEVIATION:	9.0026	9.4896
VARIANCE:	81.047	90.052
NUMBER OF VALUES:	10	

INDEX	ERROR100 VARIABLE
1	11.285
2	6.6232
3	9.4480
4	8.8513
5	-1.2580
6	-1.6391
7	-14.978
8	-11.530
9	-9.9734
10	3.2306

APPENDIX D

TABLE 8 - CONTINUED

	MAXIMUM LIKELIHOOD ESTIMATES FOR POPULATION PARAMETERS	UNBIASED ESTIMATES FOR POPULATION PARAMETERS
ARITHMETIC MEAN:	0.23158E-03	0.23158E-03
STANDARD DEVIATION:	5.3665	5.6568
VARIANCE:	28.799	31.999
NUMBER OF VALUES:	10	

INDEX	ERROR125 VARIABLE
1	1.5096
2	1.3101
3	-0.60627E-01
4	4.1546
5	3.2719
6	-0.20387
7	-3.3597
8	10.252
9	-8.2297
10	-3.6422

	MAXIMUM LIKELIHOOD ESTIMATES FOR POPULATION PARAMETERS	UNBIASED ESTIMATES FOR POPULATION PARAMETERS
ARITHMETIC MEAN:	-1.5951	-1.5951
STANDARD DEVIATION:	6.5851	6.9413
VARIANCE:	43.363	48.181
NUMBER OF VALUES:	10	

INDEX	ERROR150 VARIABLE
1	-0.26071
2	-2.0974
3	-2.6706
4	-8.1006
5	-4.2361
6	10.297
7	1.2740
8	-9.3025
9	-9.6291
10	8.7749

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APPENDIX D

TABLE 8 - CONTINUED

	MAXIMUM LIKELIHOOD ESTIMATES FOR POPULATION PARAMETERS	UNBIASED ESTIMATES FOR POPULATION PARAMETERS
ARITHMETIC MEAN:	0.14344	0.14344
STANDARD DEVIATION:	→ 5.7911	6.1044
VARIANCE:	33.537	37.263
NUMBER OF VALUES: 10		

INDEX	ERROR200 VARIABLE
1	11.142
2	1.4847
3	-3.7498
4	-0.99747E-01
5	-2.8979
6	-2.5890
7	-0.93391
8	-4.4471
9	-6.3893
10	10.515

	MAXIMUM LIKELIHOOD ESTIMATES FOR POPULATION PARAMETERS	UNBIASED ESTIMATES FOR POPULATION PARAMETERS
ARITHMETIC MEAN:	-1.7175	-1.7175
STANDARD DEVIATION:	→ 5.0574	5.3310
VARIANCE:	25.578	28.420
NUMBER OF VALUES: 10		

INDEX	ERROR300 VARIABLE
1	0.48499
2	5.1276
3	0.41170E-01
4	-5.0044
5	-1.7516
6	-3.1561
7	-6.9899
8	-4.5313
9	-9.3667
10	7.9715

TABLE 8 - CONTINUED

		MAXIMUM LIKELIHOOD ESTIMATES FOR POPULATION PARAMETERS	UNBIASED ESTIMATES FOR POPULATION PARAMETERS
ARITHMETIC MEAN:		0.70536	0.70536
STANDARD DEVIATION:		7.0570	7.4387
VARIANCE:		49.801	55.335
NUMBER OF VALUES:	10		

INDEX	ERROR400 VARIABLE
1	2.9330
2	11.261
3	1.4448
4	-0.63613
5	1.1929
6	0.18946
7	4.7662
8	7.8125
9	-15.419
10	-6.4915

GENERAL ELECTRIC

Space Division

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